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Forthcoming Events.

JUNE 8.

British Foundrymen's Association (London Branch).—Visit to the Diamond Foundry of Davis Gas Stove Co., Ltd., Luton.

AUGUST 6, 7, & 8.

British Foundrymen's Association—Annual Convention, to be held at Cardiff.

NOTES AND COMMENTS.

The Grading of Pig-Iron.

As noted on another page, the old vexed question of the grading of pig-iron was recently discussed before the West of Scotland Iron and Steel Institute, and once more many divergent views were expressed, the foundryman adopting the attitude that the pig-iron maker should supply his metal to analysis, and the latter in return suggesting that the foundryman should first say what he wants. There is, no doubt, much in the contention that many foundrymen have by no means any clear idea of what they really do want; for as one blast-furnace man remarked, "he found a great difficulty, when he got an order, in knowing what was actually wanted." Given a standard system whereby the exact requirements of the foundryman may be expressed, there should be little difficulty on the part of the blast-furnace man in meeting those demands properly. Blast furnaces, it must be remembered, are conducted on much more highly standardised and scientific lines than foundry furnaces, and the control of the product is within certain limits a matter of everyday practice. But before the blast-furnace man attempts to meet the demands of the foundryman more accurately the latter must have some definite system of expressing his requirements which will be intelligible to the maker. At present he has no such system. As has been frequently pointed out, the conditions under which the old fracture grading system developed and proved fairly successful no longer exist; the ores now used are not the same, and are far more liable to variations in character; blast-furnace operations are conducted on a different scale and at a faster rate, giving a very different result to the old, slow standard methods—methods which over long periods did not vary materially and which gave a regular and recognised product. But even at the present time a good many furnaces produce irons of very regular compositions, and foundrymen who rely on such irons do not often get misled.

As regards the difficulty of gauging the value of the iron from the fracture, it is well to remember that the defects of that system do not wholly discount its value. The foundryman is often derided for paying more for certain pigs from one melt, on account of the fracture, than for other pigs from the same melt, but that practice is based on sound reason. He has found that a certain fracture (which incidentally is largely governed by cooling conditions) accompanies certain properties in the metal. The ultimate analysis of another iron may be the same, but the properties are not; and so the foundryman allows his experience to guide him. We would again, in this connection, lay stress on the fact that the chemical analysis of an iron, as determined in the laboratory, does not indicate the condition of the constituents, particularly the graphite; and since the distinctions in properties conferred by different conditions of the constituents are not obliterated in re-melting at the low temperature of the cupola, some additional means of grading must supplement analysis. Microscopic

examination is the best method of determining the conditions of the constituents, and the foundryman in judging by fracture is only using a substitute (truly an extremely crude one) for such examination.

The suggestion that every foundry should have its chemist, we do not regard as practicable, mainly on account of expense. But that does not mean that the foundryman shall not use analysis. He might accept the blast-furnace analysis if such were supplied, and check it occasionally by means of an independent determination. Many foundrymen have acquired a very good knowledge (perhaps unsystematised in most cases) of the results to be obtained from irons of different analyses with certain fracture characteristics, and the variation in the properties of different makes of iron with approximately the same analysis and the same fracture are not so material as to greatly affect the final results. Much information is gradually being collected respecting the effects of variations in different constituents, and this information will greatly aid in formulating the required standards of composition which will undoubtedly be used in the future in selecting foundry irons. It is necessary to first establish the general relationship between fracture and physical properties; then a consideration of the composition of an iron having a certain grade of fracture should give a fair idea of the properties of that iron in a casting or its effect in a mixture.

The Situation of Manufacturing Establishments.

The concentration in large manufacturing centres of the nation's industries has been a marked feature of the last century, and has presented a number of problems which are often the despair of the social reformer. To some extent this concentration in restricted areas has been inevitable in the growth of certain industries, particularly in the case of some branches of engineering which are largely dependent on allied branches; convenient access to raw materials, and to the direction of the disposal of the finished product has been the dominating consideration, with the result that it has come to be an accepted principle that an industry can best be established in close proximity to its allied industries. Associated with this movement towards concentration has been a corresponding rise in the value of land and buildings in town areas, with its accompanying increase in the cost of living for the workers and a general rise in the cost of operating factories or works so situated. The numerous sociological problems peculiar to manufacturing centres that have developed with this concentration are too well known to require enumerating; but the position may be summed up as that of the advantages being largely counterbalanced by the disadvantages. It is not surprising, therefore, to find that the last decade or so has witnessed a reactionary movement, in the direction of works being established in outlying districts—works which previously would never have been contemplated except in dense industrial centres; and while the pioneers in this movement have been criticised strongly at times, it cannot be denied that there is an increasing tendency, in the case of establishments which are not absolutely dependent on close proximity to busy centres, to go farther afield and give consideration to other facilities than those afforded by immediate contact with large towns. Transport facilities and ease of communication have, of course, done much to aid this movement, for what were a few years ago isolated districts are now for most purposes in close touch with a number of large busy centres. Such industries as that of iron production will probably never flourish far from the source of supply of raw materials, coal, and ore; but the manufacture of iron and steel in many of its more finished forms is not so restricted, particularly in the case of engineering specialities. As the advantages of less crowded and more healthy localities become more appreciated, there will undoubtedly be witnessed the establishment of numerous works in spots at present by no means associated with manufacture.

What are the advantages of such localities from a manufacturing standpoint, which off-set the facilities offered by the densely-populated towns? In the first place, site values are far lower, and the expansion of factory space is accordingly not restricted as it is in centres where every inch of land is at a premium and the extension of works has to be postponed until a definite return for the outlay is clearly in view. It is a very important feature in the operation of town factories that what may be only a temporary increase of business cannot generally be met by extension of working capacity, on account of the heavy cost should such extension be forced to lay idle for considerable periods. Taking London as an example, there are many concerns in which the lack of space for increased building accommodation alone prevents due expansion, with the result that operations are by frequent spells conducted under crowded and inconvenient conditions. But, perhaps, a still greater advantage to the credit of country situations is the improvement of working and living conditions for the employés. It is becoming more and more evident in the engineering trade that the quality of the output is greatly affected by the physical, mental, and moral condition of the workman; and there will be few employers to-day who will refute the argument that the education of the worker which is necessary for the efficient operation of an establishment must be accompanied by good working and living conditions. The question of efficiency thus resolves itself into a sociological, as much as a commercial, problem; for despite the great advances which are continually occurring in the use of machinery in place of manual labour, the call for a higher intelligence in the worker is persistent—in fact, the development in the efficiency of the worker should follow closely the development in the use of machinery.

Such, then, we consider, must be the inevitable tendency in the future: the seeking of situations for works which will offer ready facilities for normal growth, while affording, also, healthy conditions for the employés. It should be remembered, too, that the generation of electric power for works operation and lighting by self-contained plants is, to-day, a simple matter, even for comparatively small concerns, and thus relieves them of the dependence on the large town power stations. The transport costs for coal and other raw materials, further, are often no greater for country works situated in reasonably close touch with railway systems than are the costs incurred in this direction by town factories; while the development of mechanical road transport of itself solves a number of former problems. This movement from the congested areas is certainly in the right direction, and will continue.

Questionable Aluminium Castings.

It is curious to observe what a number of alloys containing a good proportion of aluminium but also a large amount of other metals, are sold to unwary customers as aluminium. So great are the additions of other metals by some unscrupulous makers that the alloy possesses few of the essential features of aluminium castings. It is not uncommon for users wishing to employ aluminium, to obtain quotations for the castings without specifying the alloy to be used, with the result that abundant room is left for sharp practice on the part of the maker. Take, for

example, the zinc-aluminium alloys, containing, say, up to 25 per cent. of zinc. These give strong, clean castings, if properly cast, while the essential lightness of the aluminium is not greatly sacrificed; but unless the product is checked there is a tendency to introduce an excess of zinc—a practice which well pays the founder who is charging by weight, since zinc is about one-third the price of aluminium. Alloys consisting of over 60 per cent. of zinc have been purchased by some users, for motor-car crank cases and similar parts which have not to stand a great stress, in the belief that aluminium alloys of great strength were being obtained. To anyone who has studied the aluminium-zinc series at all, the absurdity of this will be apparent; and it is really strange that the weight of the castings does not tell its own tale of surplus zinc. For all purposes where strength is a feature, from 20 to 25 per cent. of zinc gives the best range of results, and when much over 25 per cent. is introduced the alloy is of quite a different nature. The aluminium-strengthened zinc (for such it really is) mentioned above is doubtless a very useful alloy for some purposes, and gives remarkably clean, nice-looking castings—a feature which may explain its success in competing with the lighter alloys; but it is out of place where strength and lightness are requisite, such as in motor-car construction. Apart from this, too, there is the commercial side of the question. With aluminium at, say, £68 a ton, and zinc at £26, half a ton of castings of a 25 per cent. zinc alloy would cost in metal about £28 15s. 0d., but with 50 per cent. of zinc the cost would be about £23 10s. 0d. This allows unfair competition with makers who are offering a good, strong casting, and is detrimental to the interests of the trade, since it cannot ultimately give satisfaction to the user.

The Tin Pest.

This disease of tin, which occurs at low temperatures, was recognised half a century ago by certain metallurgists, though even now it is not well known. Discussing the subject recently in an address before the Faraday Society, Professor Cohen stated that in certain instances blocks of bright, white Banca tin, which had been kept in store the winter, had turned into a dull grey powder and had begun to crumble. On investigation it was ascertained that the case was due to the exposure of the metal to cold. The attention of Professor Cohen was first drawn to the matter when a badly-corroded block of tin was returned by a Moscow firm, because an adulteration was suspected. The tin was found to contain not more than 0.05 per cent. of impurities. In his experiments with this material, he found that the case of white and grey tin is much the same as that of ice and under-cooled water. According to the theory he evolved, all tin should turn grey when the temperature falls below 64 degrees Fahr., and investigation showed that this was the case, but that the change proceeded very slowly at ordinary temperatures. At 23 degrees Fahr. the change was very marked, as shown in the case of a block of good Banca tin placed in contact with grey tin, while another block kept at a temperature of 59 degrees Fahr. was not badly corroded after eight years.

The decay or transformation starts from the particle of grey tin in the same manner as a small crystal of ice dropped into under-cooled water will becomes the nucleus of crystallisation. In a similar manner, every particle of grey tin becomes a centre for the formation of more grey tin, the transformation proceeding very slowly in the dense metal, the particles of grey tin acting like the germ of disease; and in this sense it may be said that the tin is infected and that all tin is liable to infection with the tin disease or tin pest. The disease does not appear to affect alloyed tin, but in what manner the presence of other metals confers immunity is not at present understood. Terne plates, for example, whose coating consists of a lead and tin alloy, give good service in refrigerating plants, while tin plates always fail. The grey tin is not oxide, although it contains some oxygen, as naturally it oxidises more readily than the compact white tin. This oxidition may prevent the ready re-conversion by heat of the grey tin into ordinary white tin, but re-fusion of the grey tin with the addition of some carbon to reduce the oxide always yields good white tin again.

American Brass Founders' Association.

It has been decided by ballot of the members of this Association that the name of the Association shall in future be the "American Institute of Metals." It was also decided that the article of the constitution which reads—"This Association shall meet in Convention each year at the time and place that the Annual Convention of the American Foundrymen's Association is held," be changed to read: "This Association shall meet in Convention each year at the time and place selected by the Executive Committee." The two changes, having been carried by a very large majority, will take effect as soon as it is possible to make the necessary changes and announcements.

1912 Convention in Buffalo.

The date for the 1912 Convention has been definitely set for the week of September 23. The exhibition will open on Monday, of that week and the sessions of the Convention proper will be held Tuesday, Wednesday and Thursday, possibly running into Friday. Arrangements have been made for headquarters at the Hotel Iroquois, and the meetings of the Association will be held there.

The following is the list of Papers and addresses so far arranged for the meetings:—

"The Electric Furnace for Brass and Bronze, and its Efficiency," by G. H. Clamer, Ajax Metal Company, Philadelphia.

"The Influence of Pouring Temperature on Manganese Bronze," by H. W. Gillett, Aluminum Castings Company, Detroit.

"The Successful Handling of Manganese Bronze and Other Alloys in a Reverberatory Furnace, or Foundry Tests and Foundry Practice," by W. R. Dean, Hyde Windlass Company, Bath, Maine.

"Progress of Work on Boron Suboxide as Used as a Deoxidiser in Non-ferrous Metals," by E. Weintraub, General Electric Company, West Lynn, Mass.

"The Rare Earth Metals, with Especial Reference to Pyrophoric Alloys," by Dr. A. Hirsch, New York.

"Phenomena Connected with the Tarnishing of Metals," by Prof. C. F. Burgess, University of Wisconsin, Madison, Wis.

"Vanadium Alloys," by G. L. Norris, Pittsburg.

"Work of Bureau of Mines as it Relates to the Non-Ferrous Metal Industry," by Prof. C. L. Parsons, Bureau of Mines, Washington, D. C.

"The Practical Use of the Equilibrium Diagram," by Dr. Wm. Campbell, Columbia University, New York.

"The Difficulties Experienced in Casting German Silver," by C. P. Karr, Standard Sanitary Manufacturing Company, Louisville, Ky.

Works of George Kent, Limited.

On Saturday, May 4, the members of the London Branch of the British Foundrymen's Association paid a visit to the works at Luton of Messrs. George Kent, Limited, hydraulic engineers. The party, numbering over 40, were met and conducted over the various departments by Mr. C. W. Escott, works superintendent, Mr. F. J. Emblem, foundry manager, Mr. J. Ellis, ironfoundry foreman, Mr. G. H. Barrett, brass-foundry foreman, and other members of the staff. Increased interest was added to the visit owing to the fact that the directors of the firm had kindly arranged to keep the foundries working during the afternoon while the visitors were present—a courtesy which was much appreciated.

The works are finely situated at the outskirts of Luton, in a position commanding a wide stretch of country. The ground occupied is several acres in extent, a good proportion of which is covered by buildings. Most of the buildings are erected on the saw-tooth roof principle, a system which gives well-lighted workshops for all departments, and the general lay-out of the works has been designed with a view to convenience.

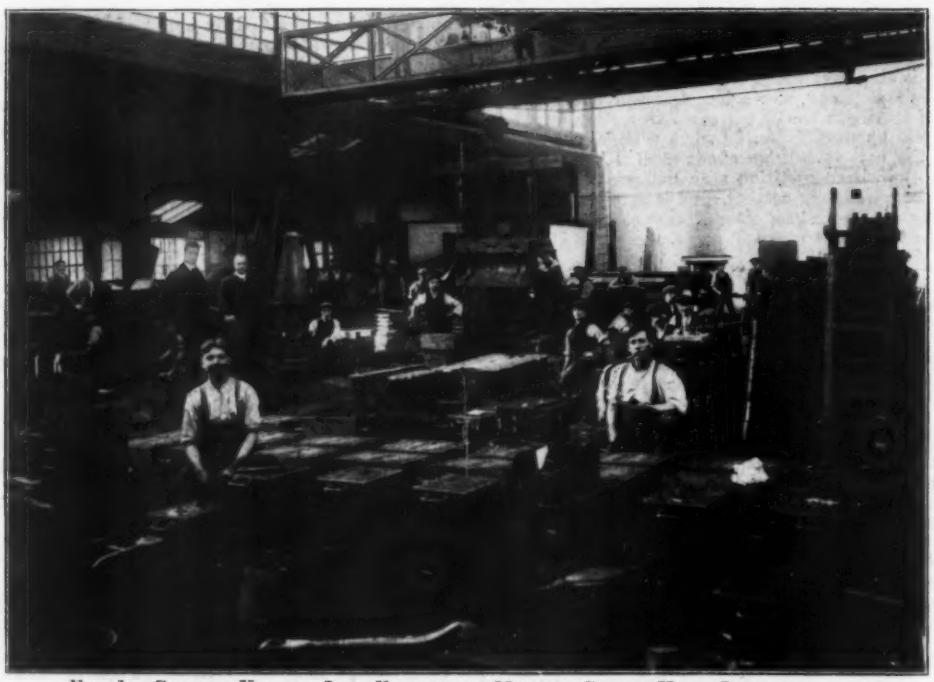


Fig. 1.—General View in Iron Foundry of Messrs. George Kent, Limited.

The visitors were first conducted to the iron foundry, a building 120 ft. long by 80 ft. wide, and 40 ft. high to ridge. This building comprises a wide centre bay supported by structural steel columns, and low bays on either side. The whole area of the centre bay is covered by a gantry crane and travelling hoist, making the handling of the metal ladles, heavy castings, moulds, etc., a simple matter. The cupolas (two in number) are of the drop-bottom type, with a fixed receiver; the blast is supplied from an electrically-driven blower direct coupled. The cupolas are placed outside the end of the foundry building, and the receivers discharge inside at the end of the gantry run-ways, the charging floors being accessible by stairs outside the foundry, and an electric hoist is employed for raising the iron to charging platform. On tapping the receiver the metal is conveyed in a large ladle by the crane, and is either poured direct in the case of large moulds or into hand shanks for small work. Since much of the work turned out in this department is connected with the firm's well-known water-meters, and is accordingly repetition work, moulding machines to the number of four are employed—three Herman's and one Ajax—operated by compressed air.

The work ranges from meter cases and parts weighing a few pounds to hydraulic flanged pipes and similar castings weighing several tons. The sand used for moulding in this department is red Mansfield milled, the milling and mixing being done in a small building outside the foundry. The lighting in this department is by electricity, the system adopted being five powerful arc lamps in the centre bay and clusters of filament lamps under large shades under the crane and in the small bays.

Leaving the iron foundry, the visitors were conducted to the brass foundry, which is situated in a separate building, about 80 ft. long by 80 ft. wide. This is a brick erection, with iron sashes all round for lighting, in addition to a good roof light in the hipped roof.

The building is divided into two bays, and the roof is supported by a row of structural steel columns across the centre of the building. That part of the floor on which heavy work is done is covered by overhead travelling cranes. The melting is done in three tilting crucible furnaces, coke-fired, the

two smaller of these being M.R.V. furnaces with 250 lbs. capacity per charge, and the larger one a Morgan furnace of 450 lbs. capacity. As will be understood, the work turned out here is again largely connected with the firm's water meters, and some very fine specimens of casting work were seen in the course of production. For moulding, Mansfield sand is again employed, and while machine moulding finds considerable application, hand moulding is also a prominent feature. Adjoining the brass foundry are the lavatories set apart for the use of the employés in the foundries. These are tiled with the firm's patent "Crystopal" tiling, and have a constant supply of hot and cold water, which is greatly appreciated. The artificial lighting of the brass foundry is by means of incandescent filament lamps. Under ordinary circumstances, however, artificial lighting is not called into play.

Passing from the brass foundry, the visitors entered the machinery department, where a very large variety of machine tools are situated for producing the various complicated mechanical parts turned out by the firm in connection with their work. The machining work is divided into separate departments, according to the class of meter made, among which are the following:—Venturi meters for measuring large volumes of water, sewage, slimes, etc., in pumping or delivery mains; Standard meters (positive reciprocating piston), for domestic, small trade, and mixed supplies, and for all small flow purposes; Uniform meters (positive rotary balanced piston), for large trade and general muni-

FIG. 2.—CORNER OF MACHINE BAY AND TRIMMING SHOP; BRASS FOUNDRY OF MESSRS. GEORGE KENT, LIMITED.

FIG. 3.—GENERAL VIEW IN BRASS FOUNDRY OF MESSRS. GEORGE KENT, LIMITED.

cipal work, and for hydraulic purposes; and air meters, for measuring supplies of compressed air to mines, etc. In the Venturi department there was on view an apparatus being constructed for a large waterworks in South America, for recording on a dial and diagram in the engineer's office the flow of water from several different points of works.

Visits were next paid to some other departments, including the meter-testing shops.

At the conclusion of the visit the company were assembled in a hall situated in the grounds, provided for the entertainment and use of the works' employés. Here they were entertained to tea by the firm, and, at the conclusion, the President, Mr. J. Oswald, rose to propose a vote of appreciation and thanks to the firm of Messrs. George Kent, Limited, thanking them for the manner in which they had thrown the works open to the Association and for the courtesy of keeping them in operation during the visit. He also spoke of the kindness of the staff in giving up their afternoon for the visitors' benefit.

Mr. J. W. Horne, Vice-President, in seconding the proposal, commented on the lovely situation in which the works were established, and on the manner in which the grounds were laid out. He believed that the future would see nearly all new works being established, not in the heart of a town, but in such spots as this, where considerations could be given to the establishment of similar excellent conditions for the men. He commented on the attention which had been paid in constructing these works and the convenience and healthy working conditions for the employés. To improve the output of any works it was necessary to educate the men; but an essential in such education was improvement in the conditions of labour.

Mr. Escott acknowledged the vote of thanks on behalf of the firm, and regretted the absence of Mr. Kent, who had hoped to have been present, but was prevented from doing so, being called away on business. He expressed every satisfaction and pleasure in meeting such a body of men, whose aims were in common with those of the firm, namely, the advancement of technical knowledge. Commenting on Mr. Horne's remarks, he drew attention to a number of other pleasing facilities for the employés, and acknowledged that the firm were greatly interested in the improvement of working conditions. They had, for example, in view the construction of a bowling-green inside the main gates, a feature of which would add a pleasing touch to the general appearance. There was also a large stretch of kitchen garden attached to the works which was well employed. He mentioned, too, that some of their present employés had been with the firm upwards of 15 years, which in itself was a testimony to their endeavours to consider the advancement and comfort of the men.

Works of Commercial Cars.

Since at the conclusion of this visit there was still a considerable amount of time available before the departure of the London train, the visitors were kindly invited to inspect the adjoining works of the Commercial Cars, the foreman pattern-maker of which, Mr. J. W. Worrall, is a member of the Association. That gentleman accordingly conducted a party over the different departments, including the pattern shop, in which he exhibited some novelties in core-boxes, the fitting shop for engines, and the erecting department, where complete commercial motor-cars up to 100 h.p. are turned out. A speciality produced by this firm is a large charabanc, of which a considerable number were to be seen in various stages of construction, including a completed car. The non-ferrous members of the Branch were considerably interested in specimens of aluminium castings, which are largely used with these cars. Another feature of interest was specimens of electric-furnace steel castings, produced at the Braintree Foundry (illustrated in our issue of April), which were employed in place of the steel forgings usually used. Other features of interest which may be mentioned in passing were case-hardening furnaces for case-hardening the teeth of gears which were being milled from the solid steel bar, and a large range of machine tools for finishing the various engine and car constructional parts. This visit formed an interesting conclusion to the day's entertainment.

Troubles with German Silver Castings.

Like most other of the non-ferrous alloys, German silver has been produced of very varied composition; and since different alloys need somewhat different treatment and are suitable for different purposes, trouble is often experienced by those not fully alive to this. As an example may be taken the copper-nickel-zinc mixture containing a small proportion of aluminium, a useful formula being Cu. 50 per cent., Zn. 34.9 per cent., Ni. 15 per cent., and Al. 0.1 per cent. The aluminium addition is made by melting together 19 parts of zinc and 1 part aluminium, pouring the alloy into small bars which can be broken up, and adding 2 per cent. of this in the final mixture. This metal casts well in green-sand moulds, and is useful for many purposes, as it is white and strong, but if employed for such work as cocks, valves and plumbers' goods does not give satisfaction, as the castings frequently develop leaky places. This defect appears to be directly associated with the aluminium. The latter metal, however, when introduced in the proportions of about 2.75 per cent. into an alloy with Cu. 65 per cent. and Ni. 32.25 per cent., gives a resulting metal with considerable strength and hardness, which is, nevertheless, not brittle. An increase in the aluminium content will give a stiffer alloy, and aids the founding operations by reason of the metal being more fluid. Care, however, must be exercised, and the use to which the castings is to be put must be considered. In the case of the first alloy mentioned trouble is often incurred by pouring the metal too hot, as it melts very easily. It should on no account be poured too hot, the best temperature being when only a little smoke rises from the metal.

The frequent remelting of scrap German silver for rolling will cause considerable trouble, since the absorption of carbon renders the metal too hard and brittle for successful rolling. Such scrap is only suitable for castings that have not to be rolled, as the hardness is then usually not detrimental.

Perhaps, however, the most serious difficulty experienced by founders who do not understand German silver is that resulting from too slow melting. To melt the metal too slowly, or to allow it to soak in the fire is to run great risk of having the castings full of pin-holes or blow-holes. The correct way is to bring the metal up to the right temperature (varying somewhat according to the mixture) and pour at once. Otherwise what may look like clean, sound castings will probably show a very defective interior on examination. The German silvers require rather more care and attention in casting than do the brasses, and this fact is sometimes liable to be overlooked. If difficulty is experienced with oxidation, manganese in small quantities (0.15 to 0.2 per cent.) is the best deoxidiser to use, and is, in fact, the standard means employed by makers of German silver.

The Patterns of Gears Derived from the Helix.—I.

By Joseph Horner.

Each of these gears, spiral, helical, and worm, though diverse in appearance and proportions, have this in common, that they are based on and derived from the helix, and their teeth are screws, or portions of screw threads. This fact helps to a clearer understanding of the work of their production. There is one exception which is more apparent than real, that of the worm gear, the teeth of which are made to envelope the worm. But in principle this also is seen to be based on the helix, though the teeth if fully developed would not be recognisable as such. The want of a clear appreciation of this fundamental basis is a reason why some young pattern-makers experience difficulty when entrusted with such gears. The term "pitch" if used loosely is also embarrassing. It should be prefixed by one more precise. If stated thus, and the basis of such gears is grasped, difficulties will mostly vanish.

The term "spiral gears" is not a happy one, since there is no spiral involved. These are screw gears, just as the worms and their wheels are, and as helical or herring-bone gears are. In each case each individual tooth forms a short portion of a true screw. (In the common worm the thread is one entire turn, or two or more turns of a screw). The screw basis is partly disguised, because the lengths of the "teeth" are very short in proportion to the lengths of the screws of which they form sections. Thus in Fig. 1, the thick black lines indicate the relations which the spiral, or the single-helical, A, and the double-helical teeth B, bear to the complete helix or screw, the total "lead" of which equals that of the length of the cylinder drawn. In Fig. 2 the "lead" or "pitch" P of the worm is small, while the lead of the worm wheel is extremely long—it would be several feet in length—and is in fact not taken into consideration, but only its circular pitch P. The angle of the teeth is taken, and that is really the angle of the spiral. Obviously, therefore, a spiral gear may be regarded as a multiple-threaded worm of long pitch, and a worm as a spiral of much shortened pitch. But there is a border line when even this distinction is no longer correct. It occurs in the case of spirals of very low angle and short pitch on the one hand, and in multiple-threaded worms of long pitch on the other, in which each thread becomes a long spiral tooth.

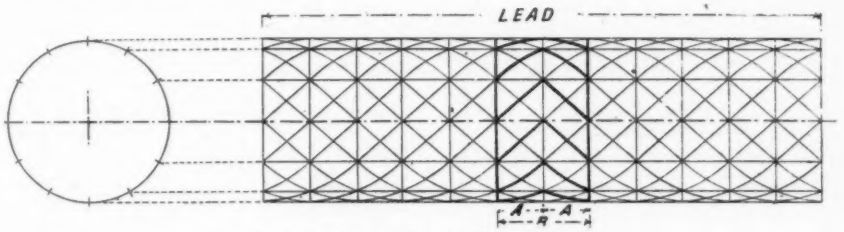


Fig. 1.—Elements of Spiral Gears.

The fact that the teeth of worm wheels usually form envelopes of their worm threads is simply a by-issue which does not alter the common relation.

Another difference between spiral and worm gears, though not an essential one, lies in the lower and higher velocity ratios that are usually obtained respectively in the two. Spiral gears rarely embody ratios exceeding two or three to one, and they are more frequently equal in ratio. But worm gears generally have ratios of from 1 to 10, or 1 to 12 onwards to almost any extent. But this also is a by-issue, since it is practicable to gear worms and true worm wheels in equal ratios, and also to make spiral gears with high ratios, as high in one type as any that are used in spurs, bevels, or worms. The most familiar illustration of this kind occurs in the double-helical wheels, which are true screw gears, and in which pinions having as few teeth as seven or eight are not very unusual. The difference between these and the spiral gears proper is due simply and essentially to the relative positions of their axes, and of the

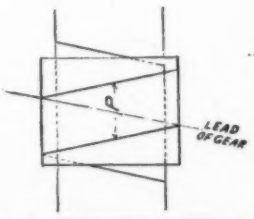


Fig. 2.—Elements of Worm Gears.

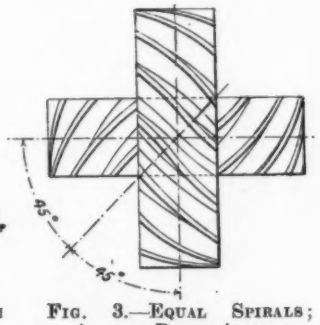


Fig. 3.—Equal Spirals; Axes at Right Angles.

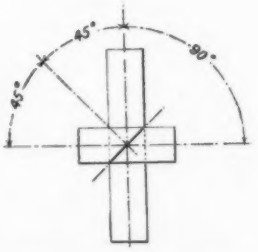


Fig. 4.—Unequal Spirals; Axes at Right Angles.

directions of the spirals. The axes of spirals cross at right angles, Fig. 3, and the mating spirals are of the same hand, with the result that the friction is of a sliding character absolutely. The axes of the helical wheels are parallel, and the spirals are of opposite hand, and the friction is rolling absolutely. But the "teeth" in a helical wheel of 6 ft. diameter are in principle as truly portions of long screws as are those in a spiral gear of 6 in. diameter, or as those of a worm and its wheel are.

The substitution of screw gears for spur or bevel gears is made for several reasons. First, they provide means for changing the direction of shafts from parallel planes to planes at right or any other angles. Second, in the form of worms and their wheels, and also of helical gears they furnish often the only available means of reducing a high speed to a low one at a single reduction. And in the helical gears they supply an absolutely ideal rolling contact of teeth which cannot be obtained in the best designed spur, or bevel, or worm gears. The disadvantage of screw gears in the form of spirals or worms and their wheels is that the contact is wholly of a sliding character. So that we have exactly the same kind of tooth producing precisely opposite effects under different arrangements.

If two spiral gears are of equal size, Fig. 3, the angles of the spirals, and the circular and normal pitches are each alike. If they are of unequal dimensions, having unequal numbers of teeth, Fig. 4, and the angles of the spirals are the same, the circular and the normal pitches, C. P. and N. P. respectively, Fig. 5, are also each alike. If the angles are different the circular pitches will vary. But the pitches measured perpendicularly to the direction of the spirals, the normal pitches N. P., Fig. 5, must be alike in any wheels that gear together, irrespective of their diameters.

One feature of much value in the spiral gears is that they can be varied both in diameter and angle to suit various drives. Differences in diameter affect the length of lead and therefore the angles, and the angle of one wheel must be the complement of its fellow. Thus, if wheels have tooth angles of 45 degrees and of the same hand, 45+45=90 degrees, and the shafts are therefore at 90 degrees, Figs. 3 and 4. If one of a pair at 90 degrees of angle has its teeth at 60 degrees then the teeth of its fellow must be at 30 degrees. But if two gears have equal numbers of teeth and their shafts are not at right angles but, say, set at 50 degrees, then the teeth must have angles of 25 degrees. A wheel of 45 degrees of angle will work with a rack if the rack teeth are set at 45 degrees of angle, and the shaft of the wheel will lie parallel with the rack; and a spiral gear will mesh with a square rack, but at an angle which will vary with the angle of spiral. We have, then, these dimensions to consider: number of teeth, angle of spiral, circular pitch, and normal pitch. A simple diagram will help to fix these relations of spiral gears in mind. In Fig. 6 the length A C, is equal to the axial pitch or lead, C B is equal to the pitch

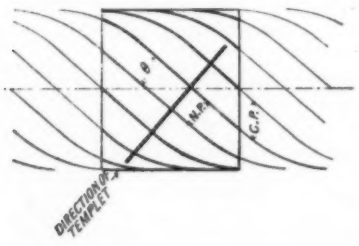


Fig. 5.—Pitches of Spiral Gear.

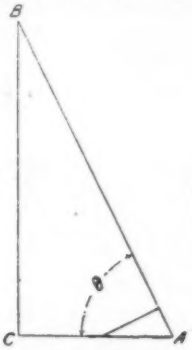


Fig. 6.—Trigonometrical Relations.

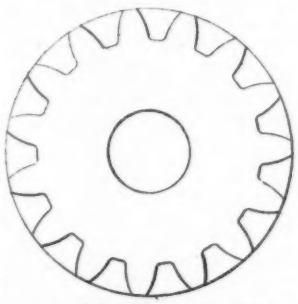


Fig. 7.—Teeth of Spiral Gear.

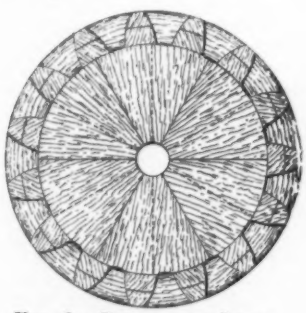


Fig. 8.—Pattern of Spiral Gear.

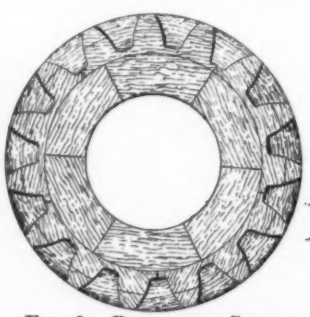


Fig. 9.—Pattern of Spiral Gear.

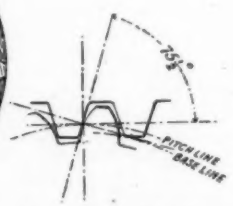


Fig. 10.—Elements of Involute Teeth.

Though spiral and single-helical gears are identical in principle, the first term is usually restricted to the smaller, the second to the larger gears. In the first the spiral is very pronounced, in the second it is, in the largest gears, scarcely apparent. Often in large pattern wheels, straight teeth have been fastened on the rim at an angle, as is done in some worm gears. And if the tooth points are well rounded off, a passable gear may be thus obtained, but these are not the true spiral teeth.

circumference, and the hypotenuse A B is the "angle of the spiral." The circular pitch is measured along the line C B, the normal pitch is at right angles with A B. From such a diagram the various relations can be laid out graphically. Or they can be calculated trigonometrically by the aid

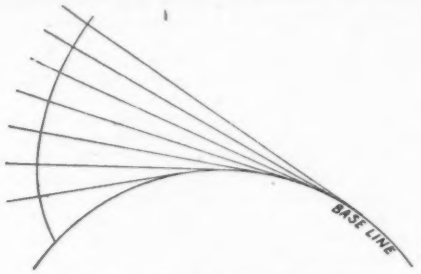


FIG. 11.—THE INVOLUTE CURVE.

of tables.

$$\frac{\text{Perp.}}{\text{Base}}\ \frac{B\,C}{A\,C} = \text{Tangent } \theta$$

$$\frac{\text{Base}}{\text{Hyp.}}\ \frac{A\,C}{B\,A} = \text{Cosine } \theta$$

$$\frac{\text{Perp.}}{\text{Hyp.}}\ \frac{B\,C}{B\,A} = \text{Sine } \theta$$

and:

$$\frac{\text{Pitch Circumference}}{\text{Tangent}} = \text{Lead}$$

The relations which these bear to the pitches are as follows:—Having the circular pitch and the angle which the spiral makes with the axis; the circular pitch × cosine of angle of spiral = normal pitch. Having the normal pitch and angle of spiral:

$$\frac{\text{The normal pitch}}{\text{cosine of angle of spiral}} = \text{circular pitch.}$$

Pitch circumference is reckoned from the circular pitch, hence for circular diametral pitch:—

$$\frac{\text{number of teeth}}{\text{circular diametral pitch}} = \text{pitch diameter.}$$

and;

$$\text{pitch diameter} + \frac{2}{\text{normal diametral pitch}} = \text{whole diameter of blank}$$

Also, for circular pitch;

$$\frac{\text{number of teeth} \times \text{circular pitch}}{3.14159} = \text{pitch diameter}$$

and;

$$\text{pitch diameter} + 2 \times \frac{\text{normal pitch}}{3.14159} = \text{outside diameter.}$$

These relations are all taken on the pitch line or pitch surface. But the angles of spiral on the pitch surfaces are different from those at the points and roots, a fact which has to be borne in mind in marking out and setting for cutting. The tooth sections are taken on the normal pitch. They are involutes, and are proportioned exactly as are the teeth of spur gears, on the basis of the normal pitch. The difference between the normal and circular pitch affects the tooth sections, which are obviously determined from the former measurement, and the tooth section is the same as that for a spur wheel having the same pitch as the normal pitch of the spiral. If the section were selected for circular pitch it would be too wide.

Small spiral gear patterns are not often made, but the larger spirals, single-helicals, are. The writer has made spiral gears for special jobs, cutting the teeth by hand. Helical gears are constructed as full patterns, but not so often as they are moulded by machine from segmental tooth-blocks. Complete patterns should properly be cut in a machine in order to secure the best results, though they are also cut by hand. The work involved in each method, taking the casting shown in Fig. 7 as an example, may now be run through.

A spiral gear pattern is made similarly to pinions for spur wheels. That is, the body may be built up in segments, or be turned out of the solid wood. The teeth may be cut in the solid with the body, or, unless very small, be preferably attached to the latter by glueing. In small gears it is not necessary to build up in segments; but if a solid block is used the grain must run parallel with the axis of the wheel, and not "plank way," which latter would generally result in an elliptical pattern after lengthy storage. Mahogany or teak wood should be used. To make the larger spiral gears strongly, the teeth should properly be separate fittings on the body. This involves fitting a separate piece for each tooth on the body, or preferably pieces wide enough to include two or three teeth, the grain running approximately at the tooth angle. In spiral and

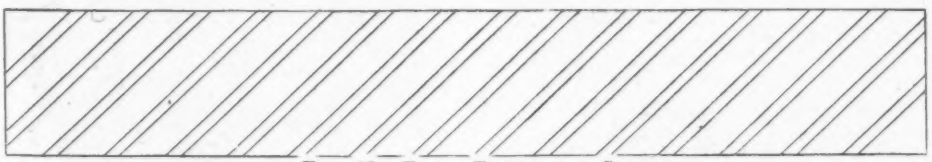


FIG. 12.—PAPER TEMPLET OF SPIRAL.

helical, as in spur gears, a good alternative to fitting each tooth-block separately, as in Fig. 8, is to turn the body smaller in diameter than the roots of the teeth, say, by ¼ in. or so, Fig. 9, and fit the stuff for the teeth round it in blocks of several inches in

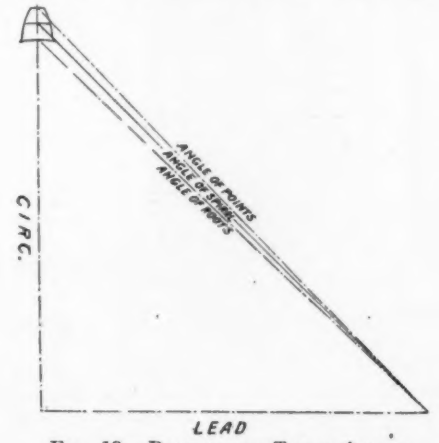


FIG. 13.—DIAGRAM OF TOOTH ANGLES.

width. When the teeth are cut there is then a substance of wood left below the radii in the roots. If this plan is adopted the blocks should be sawn diagonally to give straight grain in the teeth. These

blocks are turned on the wheel body at the same chucking as the body. Or if the teeth are cut out of the solid, using mahogany, they will with care stand a good number of mouldings from. Or if for permanent use, a metal pattern can be cast and filed smoothly, or cut in a machine, the latter being the best plan to adopt.

The pattern maker draws out the teeth for wheels of different sizes on the basis of the involute. A rack tooth, Fig. 10, has straight flanks set at an angle of 75½ degrees (75 degrees is sufficiently near) with the pitch surface, and all other gears have

FIG. 14.—TEMPLET.

single-curved teeth which can be obtained by the method shown in Fig. 11 by the unwinding of a cord from the base line. But in practice a little straight-edge, having a needle in its edge, strikes the curve on the straightedge being moved in a tangent arc on the base line of the involute, which is situated a little way above the bottom of the teeth. The curve is struck on the basis of the normal pitch, whence the tooth thickness—half that pitch—is also obtained. That is, if the normal pitch is 1 in., the tooth thickness is ½ in., and the curve is generated on the base

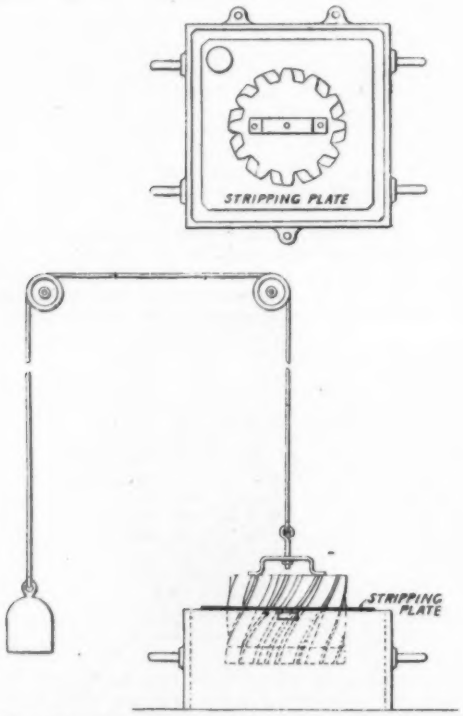


FIG. 15.—WITHDRAWING SPIRAL GEAR THROUGH A STRIPPING PLATE.

line of a 1-in. pitch tooth, even though the circular pitch may measure 1½ in. There need be no flank clearance in spirals, and only a trifle of bottom clearance. The length of tooth can be made to Brown & Sharpe proportions. The tooth shapes required are those which correspond with the diameter of a gear of the curvature taken at the normal pitch. It will always be of a larger radius than that taken around the circular pitch. A templet, Fig. 5, can be cut to the curvature of the blank, and a radius found for that curvature. The diameter of the circle struck with that radius will correspond with the outside diameter of the gear for which the tooth shapes will be obtained.

The quickest way to mark out the spiral curves for the pattern is from paper, Fig. 12, having diagonal lines ruled to represent the divided pitches, and corresponding in number with the numbers of teeth in the wheel. In the development shown in Fig. 12 the teeth are at an angle of 45 degrees on the pitch surface. The pitch circumference is calculated, being either obtained from diameter direct if this is given, or from the circular pitch, and is set off on a base line and divided into equal parts. Lines are drawn at an angle which corresponds with the angle of the tooth points. Other lines are drawn parallel with the first to represent the widths of the separate teeth. The angle on the points is obtained by setting out the lead and the circumferences on lines at right angles (Fig. 13), the latter corresponding with the pitch line, point and root respectively. Lines drawn from these to the point where the length of lead is measured will give the

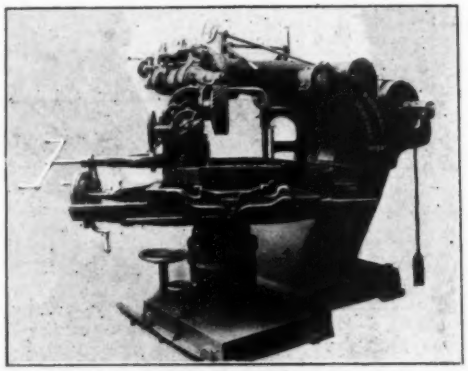


FIG. 16.—CUTTING SMALL HELICAL GEARS ON THE WADKIN WOODWORKER.

three angles of pitch line (spiral), point and root. The point lines, as already mentioned, are those which are marked on the paper, Fig. 12, which is glued round the blank turned to the diameter of the tops of the teeth. The other angles cannot be set out on the pattern, but those on the pitch circle, and on the tooth roots will be developed in working by a templet of the tooth spaces of the normal pitch.

It will be seen at once that we have no pitching round or marking out on the wheel faces yet as in spur wheels, but only at present these spiral tooth points, which are not even located on the pitch surfaces. The tooth spaces must therefore be worked by templet, Fig. 14, guided by these tooth points, and held strictly at right angles everywhere with the longitudinal axis of the teeth as in Fig. 5. The templet therefore corresponds to the normal dimensions of the teeth, and not the circular, though the diameter of the wheel is based on the circular pitch. And as already stated, two wheels may gear together even though the circular pitches differ widely, so long as the normal pitches are alike. In Fig. 14 the templet is cut to the curve of the pitch circle, equal to that corresponding with the normal pitches, as just stated. The templet must be always held at exact right

angles with the direction of the thread, which corresponds with the narrowest space, and must be kept with its shouldered portions exactly parallel with the tooth points.

When cutting the teeth with the chisel it is not easy to get them all alike by the templet, especially at their terminations, due to the templet falling out of contact with one side. The best way, therefore, is to work a couple very carefully first, and then from those, strike out the tooth shapes on the outer faces as they are developed by the templet on those

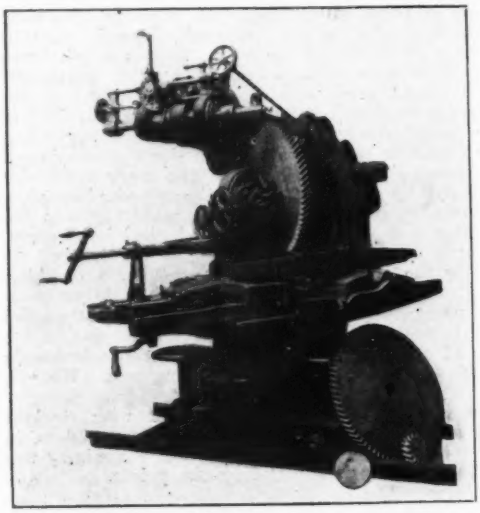


FIG. 17.—DOUBLE HELICAL GEARS BEING CUT ON THE WADKIN WOODWORKER; PINION AND GEAR (EACH IN HALVES) COMPLETED IN 60 MINUTES.

faces where the circular pitch is measured. If this is not done, the chances are that though the teeth will be true about the central portions, there will be some want of uniformity apparent on the outer faces. Another way to avoid this is to prepare the wheel an inch wider than the pattern is wanted, and then after the teeth are worked, turn ½ in. off each face, so getting into the accurately worked portions.

If a spiral gear has a wide face, a stripping-plate is essential in moulding it. A rig-up is shown, Fig. 15, for moulding an iron pattern drawn through such a plate. A shallow pattern may be drawn without such an aid, but it is a good method to adopt in any case.

Helical teeth are worked by similar methods, but they give less trouble than spirals because the angles are less, and the method therefore may be modified with advantage, a point to which we will return directly when speaking of the double-helical gears. Helical teeth seldom exceed about 20 degrees of angle, while spiral gears are mostly 45 degrees, sometimes more, in one wheel, when velocity ratios are other than 1 to 1.

The illustrations, Figs. 16 and 17, show helical gear patterns being cut in one of the mechanical woodworkers made by Wadkin & Company, of Leicester. An attachment is fitted to receive the wooden blank. The pitching and feeding are done by a universal spiral head fitted to the table. A gear, 9 in. diameter and of 3-in. face, Fig. 16, was completed in 15 minutes. In Fig. 17 the halves of a double helical gear are shown being cut.

Helical and double-helical gears having teeth set at a low angle, though closely related to the spirals, may also be considered from the point of view of action of spur gears. We will go back to the first principles illustrated by the old stepped gear from which the helicals are derived. A spur gear is cut into many parallel slices, perpendicular to the axis of rotation, and these slices are slid over one another by equal increments. Then the steps being obliterated we have the screw development. Hence the gears should be worked as spur gears are, that is, circular pitch is taken, and normal pitch disregarded, though the latter is used in working the shapes. The teeth are struck out on the outer faces and middle plane of the gear, and they are symmetrical on each side of a radial line from the pitch to the centre, as are spurs. To these the normal pitches will be proportioned. To obtain the screw form in the longitudinal direction of the teeth, diagonal lines may be marked on paper glued round, or intersecting lines may be drawn, or bending a bit or spring steel round will give the curves.

The teeth are fitted similarly to those of the spirals. The rim being turned, say, ¼ in. or ⅜ in. smaller than the diameter of the roots of the teeth, blocks are fitted round it, each sufficiently wide to include three or four teeth, the grain running along the tooth lengths, or nearly so. These are all glued on, turned on the faces and to the diameter of the points, and marked out on the outer faces and on the middle plane alike. The spiral form at the points is marked by either of the methods previously stated—by diagonal lines on paper, by lines of equal division, or with a flat piece of spring steel bent round. Then the shapes away from the ends and from the outer diameter are cut by the aid of a templet similarly to spiral gears, corresponding with the normal pitch.

Another way is this: Turn the rim to the diameter at the roots of the teeth and fit blocks round wide

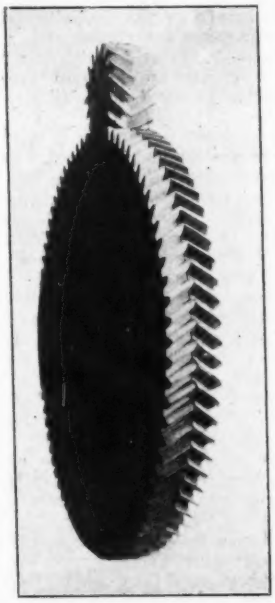


FIG. 18.—DOUBLE HELICAL WHEEL AND PINION.

enough to take three or four teeth, and secure these with a couple of screws in the centre of each. Then turn them, and mark out the teeth as before on the faces and in the joint, with the screw form marked on

the points by either of the methods previously mentioned. Having these lines, two fine screws for *each* tooth can be put through from the points into the rim. Each separate tooth will be numbered, and the rim adjacent, and the screws then will be run out and the blocks removed and sawn through for the separate teeth. Then the screw forms will be marked on the backs of the blocks similarly to the front, and the lines set in deeply and exactly with the chisel. Then the separate blocks are glued and screwed in place, and the teeth cut to templet as before. The advantage of this method is that the backs of the teeth are cut in directly, instead of trusting wholly to the templet. But this is more than discounted by the absence of a radius in the roots, which radius is worked in the first-named method. In this last, also, there is no feather-edge at the termination of the radius, but a backing of solid wood of $\frac{1}{8}$ in. or $\frac{1}{16}$ in. in thickness.

The determination of a suitable angle for double-helical teeth seems to be settled in a somewhat empirical fashion. These vary from about 20 degrees to 45 degrees. The higher the angle the greater the difficulties in ensuring equal contact of the teeth to right and left, and in balancing end thrusts. It also reduces the normal section of the teeth. There is an advantage in shortening the teeth and in adopting a pressure angle higher than $14\frac{1}{2}$ degrees, one of 20 degrees being suitable. A great advantage results in the fact that very small pinions can then be employed. Some are so small that they are almost suggestive of freak gears, but they are not so, but just helicals which engage correctly and without shock.

The sloping disposition of the teeth entails the division of the pattern along the middle plane, and the withdrawal of each half from the mould in a spiral fashion controlled by the twist of the teeth. Such being the case, arms cannot be fitted, unless they are left loosely in the encircling rim. Usually, therefore, such gears are plated with a central web, or else the pattern is made with a solid disc flush with the ends of the teeth, as in Figs. 17 and 18, and the interior is cored out similarly to machine-moulded gears.

If these gears can be cut on a machine the tentative work of the templet is saved. But as yet few pattern shops (excepting those dealing with a large number of gear patterns) have machines of sufficient capacity to take a large range of gears. Fig. 18 illustrates a pair of gears of this kind as made by Messrs. David Brown & Sons, Limited, of Huddersfield. The teeth are machine-cut, the operation occupying two hours. The gears are 25 in. and $5\frac{1}{2}$ in. diameter respectively. The body of the wheel is glued up in segments. The teeth are glued on in blocks to leave about $\frac{1}{4}$ in. of wood below the roots of the teeth.

It is not advisable to make large helical spur gear wheels from full patterns. Better results are obtained from tooth blocks moulded by machine.

In the case of helical bevels the employment of tooth blocks is even more imperative, not by reason of any difficulty in moulding, but because of the very great expense of the pattern work. There is no special difficulty in making spirals and double-helicals, since the teeth and tooth spaces are of parallel section throughout, and they can therefore be worked with hand tools and a single templet, or with a fly cutter. But bevel teeth cannot be so treated. They must be worked by hand, a most tedious job if done accurately. Let us look at the essentials.

The principles which govern the shapes of helical bevel gears hardly need be illustrated. The tooth shapes are drawn on planes projected from the ends to the axes, the point of intersection giving the centre of the projected pitch lines. The teeth are marked on these planes.

The tooth shapes are marked on the major and minor diameters, and on the plane of the apex where the right- and left-hand teeth meet, and the helical curves are marked through intersecting lines on the tooth points. Then the teeth are shaped between these locations. A templet can be used for each intermediate position, that is, midway between the major diameter and the apex, and between the latter and the minor diameter. The patterns, if such are made, must be jointed along the apex precisely as tooth blocks must be. Whether they shall remain divided or be fastened depends on the amount of coning of the gear. A gear which has a long back cone distance, *i.e.*, one which approaches to a crown gear, will deliver easily. But in the opposite condition the gear must remain divided in the mould like a helical spur. Then the upper half is withdrawn first, twisting it under the coercion of the twisted teeth, after which the lower portion is delivered by a twisting lift in the opposite direction.

Actually, circumstances would seldom justify the making of complete patterns for helical bevel gears. A large number of castings must be required off to justify the cost. It is better, even for a considerable number, to make a tooth block. More pains and precautions can be taken in working it than can well be bestowed on a full pattern, and though the cost of moulding is higher, the difference is hardly sufficient to justify making a full pattern. We are, of course, supposing that the work is done correctly with spirally twisted teeth, and not with straight bevelled teeth merely set diagonally as was done in many of the early helical gears. The inaccuracy was well masked by well rounding the points.

Oxygen Additions to the Furnace Blast.

According to the report of Dr. F. W. Lührmann, of Berlin, to the Blast Furnace Committee of the Verein Deutscher Eisenhüttenleute on this subject, the managements of furnaces in Mülheim-Ruhr, in Ougrée and in Kratzwieck are using small oxygen additions introduced into the blast whenever the furnaces are working cold. They believe that a steady enrichment of this nature would be detrimental to the furnace lining. Dr. Lührmann, on the other hand, holds that with an advanced knowledge on cooling methods this danger is not a very real one. The oxygen added is in the form of "Linde air," or 50 per cent. oxygen and 50 per cent. nitrogen. It is made by evaporating liquid air to a gas with 95 per cent. oxygen, and then further diluting with air to give the above-mentioned composition. In the case of blast enrichment, naturally, the liquid air would be evaporated directly into the blast pipe and proportioned to give the higher oxygen percentage desired. An installation to furnish 17,500 cubic ft. of oxygen per hour would occupy a space 125 ft. square, and cost about £20,000, requiring 800 h.p. to operate it. Dr. Lührmann finds that for every 1 per cent. oxygen addition to the blast volume there is a possible rise in temperature of about 100 deg. F., not taking into consideration the specific heat of gases, etc., or 2,830 deg. F., as compared with the theoretical temperature of the CO obtained by burning carbon in air. This 1 per cent. oxygen addition to the blast volume, in a furnace of 240 tons daily capacity, would add 10s. per ton to the cost of the pig-iron produced, this being based upon a cost five times as high as that given by interested manufacturers. Should their price be correct, the additional cost would drop down to 2c. a ton of pig-iron made, and this cost is well worth while investigating with a view of emergency use when trouble sets in.

Casting Ingots for Guns.

In a Paper on "The Manufacture and Treatment of Steel for Guns," presented before the Iron and Steel Institute meeting on May 10 last, General L. Cubillo, of Valladolid, Spain, included the following:—

Melting of the Steel.

Of all the processes employed in the melting of steel the only ones used in the manufacture of gun steel have been the crucible and the open-hearth processes. The first process was naturally employed before the introduction of the open-hearth method, and for some time afterwards; but the latter has now superseded the crucible process, except at the Krupp works.

Mention may be made of the great claims possessed by this firm as the pioneers in casting, by the crucible process, great masses of steel intended for gun construction. Credit must also be extended to the English firms of Firth, Vickers, and Whitworth, which also employed their energies in the improvement of this manufacture. The firm of Krupp has always claimed that the crucible process offers the best guarantee for a sound metal for gun construction. Undoubtedly it is possible to obtain by it a metal of greater purity with regard to phosphorus and sulphur than by any other process, if the material charged in the crucibles is wrought iron from hematite pig-iron. The metal obtained in this case will be the best possible steel, and it will not contain occluded gases; or at all events in very small proportion. If the metal charged in the crucibles is free from oxides, the only gases dissolved in the steel will be those which have passed through the walls of the crucibles.

In the author's opinion steel made by the crucible process must lack homogeneity, because it is almost impossible that the composition of the charge of all the crucibles will be the same. It is also impossible to secure uniformity of composition in the ingot mould, bearing in mind segregation. The only way of securing homogeneity by this process would be to teem the crucibles first into a hot ladle, and then into the ingot mould. The principal reason for this lack of homogeneity lies in the impossibility of analysing all the puddled bars which form the charge of the crucibles, classification by the eye being very uncertain. Therefore, in the author's opinion, a massive ingot of steel cast by the crucible process is more heterogeneous than a similar ingot cast by the open-hearth process. The open-hearth acid process is generally employed for the casting of great masses of steel. The basic process can, of course, be employed, provided the materials charged are acid; and there is no difficulty in obtaining by the open-hearth process, that is, by the dissolution in a cast-iron bath of a certain quantity of wrought iron or steel, a very pure metal, such as is required in the construction of guns. All depends on the purity of the pig-iron and the scrap charged.

It is the constant practice of all the steel-works where steel for gun construction is regularly made to employ Swedish pig-iron of the best quality, the phosphorus being as low as 0.025 per cent., and the sulphur lower than this amount; and for the scrap, puddled balls or bars from the best hematite pig-irons.

By puddling this pig it is possible to obtain a product with phosphorus and sulphur as low as 0.001 per cent., and as furnaces of 50 or 60 tons' capacity are now very common, and since for the casting of the largest element of the new great guns it is not necessary to have ingots of more than 100 or 120 tons, the result is that it is not very difficult to obtain a great uniformity of the metal by this process. The conditions of open-hearth working permit of working two or three furnaces so uniformly that, at the time of casting, the metal of the two or three furnaces will be perfectly similar. The steel is much exposed to the oxidation of the furnace gases, always in contact with the bath; and to this action is added that of the iron ore incorporated for oxidising in a rapid and energetic manner the silicon and carbon in excess of that required in the steel. There are many means of diminishing the oxidation of the bath; one of them is to prepare the charge by putting in the furnace the greatest possible amount of scrap, with the smallest quantity of carbon, and conducting the refining process by the furnace gases only without the addition of any iron ore. This particular method of working is extraordinarily slow; first, because, as the materials, both pig-iron and slag, are charged at once and cold, the mixed bath is very low in carbon and its melting point very high. It, therefore, requires more time for melting it than if the charge had been composed of equal parts of pig-iron and scrap. Secondly, because the oxidation of the carbon by the gases is not so efficacious as that by the iron ore, this being more in contact with the bath and the former acting only on the surface. Operating in this way the final steel is almost free of oxides, and in order entirely to eliminate them additions are made, at the end, of certain iron alloys, such as ferro-manganese and ferro-silicon, which by their action upon the bath reduce the iron oxides dissolved in it. This addition is the more required when the charge has been of equal parts of pig-iron and scrap. The percentage of carbon of such a charge at the fusion or melting time will be very high, and it is not possible to oxidise the excess carbon to the point required in the artillery steel by the action of the gases only, and it is almost imperative to employ the iron ore for accelerating the oxidation of the carbon.

Fusion at Trubia of the ordinary Carbon Steel for Guns.

The steel works at Trubia (Spain) comprise two furnaces—one of large capacity, capable of taking charges up to 54 tons, and the other of 16 tons. Therefore it is possible, working with the two furnaces, to obtain an ingot of 64 tons. The furnaces were supplied by Messrs. Frederick Siemens of London, and are of the usual design. They are situated in a straight line, with a very commodious working platform, and are served by an electric-charging crane, of the well-known Wellman type.

For the service of the casting shop there are two overhead electric travelling cranes, one of 75 tons' capacity, with one motor only of 30 horse-power, and the other a Niles 50-tons' capacity crane, worked by four motors of 130 total horse-power. The second crane of course, has been more recently installed than the first.

In the fusion of the ordinary carbon steel for guns, the materials employed are Swedish pig-iron and puddled ball from Bilbao hematite pig-iron. In order to convey an idea of the operation, a heat in the 16-ton furnace will be described.

The furnace was charged with 7.5 tons of Swedish pig-iron and 9 tons of puddled ball from Bilbao hematite. These materials are charged straight into

the furnace, the first charged being the pig-iron. At 9.2 a.m. the charge was commenced, and melted at 2.40 p.m. The first iron ore addition of 60 kilogrammes weight was made at 2.50 p.m., and another of the same weight at 3.15 p.m., followed by another of 50 kilogrammes at 3.35 p.m. During the melting period and the following 45 minutes nearly all the silicon was oxidised. Some minutes after the third iron-ore addition, the ebullition of the bath commenced, which evidently proved that the oxidation of the carbon was energetically proceeding. The iron-ore additions followed from time to time as the

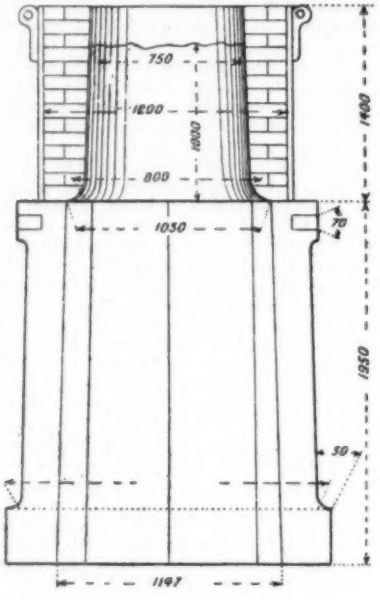


FIG. 1.—INGOT MOULD.
Dimensions in Millimetres.

state of the bath indicated the necessity. The operation is conducted with the air-valve closed as much as possible, so that the metal should not become cold, nor become oxidised. The total additions of iron ore amounted to 350 kilogrammes. At 6.25 p.m. the colorimetric analysis of the small sample taken from the bath and very slowly cooled gave a percentage of carbon of 0.52 per cent., and as the quantity required in the steel must be between 0.45 and 0.55 it was decided to tap the furnace, making previously the suitable additions of alloys. These were ferro-manganese and ferro-silicon, putting 124 kilogrammes of the first and 99 of the second; the percentages required in the metal were 0.55 to 0.65 per cent. of manganese and 0.15 per cent. of silicon. This percentage is quite sufficient for obtaining a metal totally free from side and central cavities, except those at the top of the ingot and the pipe. The metal is poured into a Wellman ladle, previously well heated by producer-gas. The ladle is then transported by the 50-ton electric crane to the casting-pit, where the metal is poured into the mould.

Ingot Mould.

The ingot mould is of cast iron, with a wash of refractory material, intended to retard the cooling of the metal at the top, keeping it fluid as long as possible, so that it may fill the space left vacant by the contraction of the metal in the rest of the mould. The mould both outside and inside has the form of a truncated pyramid (see Fig. 1). The sides of the inside pyramid, instead of being planes are curved surfaces joined to one another by rounding the edges. It seems natural that, since the elements of guns are cylindrical, the ingot moulds should also be of cylindrical form inside, and since also the steel,

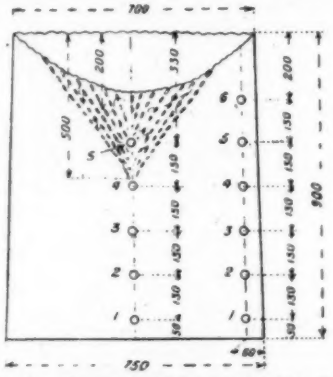


FIG. 2.—SHOWING POSITIONS FROM WHICH SAMPLES WERE TAKEN.
Dimensions in Millimetres.

as it solidifies, crystallises in crystals whose axes are normal to the surface of the mould, the cylindrical form should be the best for obtaining good sound ingots without cracks. The reverse is what happens. The ingots cast in circular metal moulds have always a deep longitudinal crack, and thus are incapable of subsequent forging. In order to avoid the occurrence of cracks during solidification and subsequent cooling on the outside surface of the ingots, they are sometimes cast in refractory moulds. But though no cracks occur in ingots cast in such moulds, the long time spent in the cooling of a large ingot, cast in such manner, produces a very coarse crystalline texture, almost impossible of being changed to the proper texture during the forging. The experience at Trubia with 40-ton ingots cast in refractory moulds has been totally adverse to their use as substitutes for metal moulds for the part of the ingot really utilised. When this is completely solidified and almost cold on its outside, it is taken out of the mould and is covered with ashes until it is completely cool. After this it is carefully examined for cracks, which are dealt with by the pneumatic hammer. As it is not an easy matter to get rid of them entirely by these means, the ingot is sent to the forging shop, where it is subjected to a slight preliminary forging, just sufficient to give it a

cylindrical form. Any cracks which were not visible in the preliminary examination then appear, and are taken out in the lathe. Some very good metal is thereby lost, but in the finishing up of the forging no cracks appear, and it is possible to finish the pieces with the least possible excess in the dimensions required for the hardening.

About half-way through casting, operations are suspended for an instant, while a very small ingot is cast from the ladle. This is intended for the full analysis of the metal, and for forging a test-piece for a preliminary tensile test.

In order to study the segregation phenomena in the unfinished steel, the head from a 16-ton ingot was divided through its vertical axis. One of the halves of this head is represented in Fig. 2. From it were taken the samples for analysing the carbon, manganese, phosphorus, and silicon. The samples were taken only in one half of the head, because it was presumed that the symmetrical parts of the other half must have the same composition, as the conditions of cooling were equal for both halves. The small ingot taken during the casting operation, which, owing to its very small dimensions, is free from the phenomena of segregation, and fairly represents the composition of the steel in the ladle (where it is supposed to be completely homogeneous), gave on analysis 0.56 per cent. of carbon and 0.57 per cent. of manganese. On comparing these per-

Analyses of Samples taken from Head of Ingot.
Centre.

No.	Carbon.	Manganese.	Silicon.	Phosphorus.
	Per cent.	Per cent.	Per cent.	Per cent.
1	0.565	0.525	0.187	0.024
2	0.672	0.610	0.210	0.029
3	1.176	0.620	0.230	0.029
4	1.607	0.620	0.621	0.036
5	2.484	0.610	0.284	0.049

Outside Surface.

No.	Carbon.	Manganese.	Silicon.	Phosphorus.
	Per cent.	Per cent.	Per cent.	Per cent.
1.	0.564	0.595	0.187	0.021
2	0.463	0.580	0.187	0.018
3	0.565	0.570	0.187	0.017
4	0.427	0.575	0.187	0.017
5	0.443	0.565	0.187	0.018
6	0.497	0.585	0.163	0.019

Analyses of small ingot taken during pouring—

	Per cent.
Carbon	0.562
Manganese	0.57

centages with those of the samples it is observed at once that there is not a very great difference between the samples taken at the circumference of the head and those of the small ingot. But the difference is very great in the samples taken in the centre of the head. Here, segregation phenomena are in evidence, especially with regard to carbon. It is observed that sample No. 1, from the bottom of the head, has the same quantitative composition as the metal of the small ingot, but in samples Nos. 2, 3, 4 and 5 the percentage of carbon increases gradually, being in sample No. 5 four times greater than in sample No. 1. The manganese increases also, but less so; the silicon more than the manganese, while the phosphorus in sample No. 5 is double that of No. 1. The layer of steel, in contact with the ingot mould, represents very nearly the composition of the metal; in fact the percentage of the metalloids is less. The layer successively cooling from the outside yields to the inside layers a certain part of its metalloids, until the central part of the ingot is reached, which, being the last to solidify and cool, is therefore richer in foreign elements. As the ingot mould is not closed, and is not in the form of a symmetrical cube, the segregation phenomena do not occur in the ordinary ingot mould in the manner described by Howe in his classical book, "Iron, Steel, and Other Alloys," as the "Onion type" of freezing. If the mould is a perfect cube, and the action of gravity be assumed to be counterbalanced, the segregation phenomena should occur in a completely regular manner, in layers parallel to the sides, and the metal richer in foreign elements will be exactly in the centre of the figure. In the casting of large ingots the segregation phenomena must occur as described, because the top of the ingot is the last to cool, especially if, as is the case at Trubia and elsewhere, the head of the mould is of refractory material, which contributes to a great extent in keeping the metal fluid longer than if this part of the mould were of metal.

About twenty years ago Brustlein explained, in a report to the "Commission des Methodes d'Essai des Materiaux" in 1892, the lack of homogeneity of steel ingots and segregation phenomena in a manner very similar to that already explained in this Paper, but without the aid of chemical analysis. His views as to segregation phenomena are in perfect accord with the manner of solidifying the iron-carbon solutions, as Roozeboom has explained in his diagram.

Applying their theories to the solidifying of steel ingots for gun tubes, it is easy to explain why the percentage of carbon increases from the outside layer in contact with the walls of the mould to the centre of the ingot, culminating in the greater amount of carbon and of the other foreign elements in the upper and central part of the ingot which is the last to set.

Fluid Compression.

Fluid compression consists, as everyone knows, in applying pressure to the steel while still fluid or semi-fluid. The process has acquired considerable development, and is extended to ingots of common steels, whereas it was at first only applied to ingots intended for the manufacture of guns or for the large shafts of ships. The older fluid compression method is that of Whitworth, whose patent was taken out in 1886, the chief object of which was to obtain cast-steel ingots free from cavities.

The Whitworth process is undoubtedly a very good one, and, considered economically, it offers great advantages, but in practice not all the advantages of fluid compression are obtained. In one of the most important French steel works, where this process is applied to the ingots intended for the construction of guns, the author has had occasion to examine some of them, and has found that the pipe at the top does not entirely disappear.

In order to demonstrate that the Whitworth fluid compression process gives homogeneous ingots—that is, ingots free from segregation—it would be necessary to demonstrate it practically by dividing a large ingot longitudinally, and taking many samples for analysis, from all parts, or at least in the upper third. It is certain that in present-day practice, with the judicious use of deoxidising alloys in the furnace, such as ferro-manganese and ferro-silicon, and perhaps with a very slight addition of aluminium during the casting operation, it is possible to obtain ingots free from cavities, except at the very top, in the central part, as is seen in the head of a 16-ton ingot, represented in Fig. 2. In this, as in all similar ingots, a very sound and homogeneous (78 per cent.) total mass was obtained. In favour of fluid compression it may be said that it causes the disappearance of the deep cracks, especially in the bottom of the ingot. Perhaps this is to

be attributed rather to the lining of the inside of the ingot mould with refractory material. The cracks are always a serious defect, and sometimes, if ingot moulds of polygonal section without rounded corners are employed, and the block, after forging, is put on the lathe, they appear as dark lines along the total length of the piece, which correspond to the angles of the ingot. Certainly in many cases the turnings do not break off when the tool cuts across the dark lines, but all the same the appearance of such lines does not suggest a very good quality of metal.

With regard to the improvement of the mechanical properties by fluid compression, the author must say that it is not very evident to him. Perhaps it is assumed that fluid compression during the last period of the process, when the metal is in a semi-fluid state and almost set, confers an effect similar to forging. In Whitworth fluid compression, after the expulsion of the gases, the press does not cause any deformation in the ingot, and there cannot be forging without deformation. Some years ago a new fluid compression process was patented by Messrs. Robinson and Rogers, of Sheffield, in conjunction with Mr. Illingworth, of New York. This process has been described by Mr. A. J. Capron.* The advantages derived are that absolutely sound ingots are obtained free from cavities and pipe, so that the whole of the ingot can be utilised, without any waste.

Another compression fluid process, which has become very well known and accepted during recent years, and is widely adopted in France, England and Germany, is that patented by M. Harmet, of St. Etienne.

In concluding this part of the Paper, the author would repeat that in his opinion the principal advantage to be derived from fluid compression lies in its economical aspect. When casting under ordinary conditions, it is possible to utilise from 75 per cent. to 80 per cent. of the ingot, while with compression it is possible to reach 90 per cent.

British Foundrymen's Association.

Annual Meeting of London Branch.

At Luton, on Saturday, May 4 at the conclusion of the visit to the works of Messrs. George Kent, Limited (see page 338), the members of the London Branch of the British Foundrymen's Association held their annual business meeting at that company's works, the entertainment hall having been kindly placed at their disposal.

Mr. J. Oswald, Branch President, occupied the chair, and after the minutes of the previous meeting had been read by Mr. T. Murphy (Hon. Branch-Secretary) and approved, the election of officers for the next session was considered.

The Chairman said his first duty as retiring President was to propose as President for the forthcoming year Mr. J. W. Horne, the closing session's Vice-President.

Mr. Horne here interposed, and after mentioning the great success of the first year of the London Branch, and the way in which the labours of Mr. Oswald had contributed to that success, suggested that that gentleman be invited to occupy the Presidential chair for another year. The work would then be much lighter, and such an invitation would be at least some recognition of the services he had rendered.

Mr. Oswald here demurred that in the interests of the Branch, particularly a young Branch, it was better to have a new President each year. He called upon Mr. J. Ellis to second his proposal that Mr. Horne be elected.

Mr. J. Ellis concurred with the opinions expressed by Mr. Horne, and expressed a desire to see Mr. Oswald again in the chair, unless he had a definite assurance that private considerations stood in the way.

Mr. Oswald having definitely stated that he could not, owing to the pressure on his time by business affairs, again accept the office,

Mr. Ellis seconded the proposal that Mr. Horne be elected. The late President, he said, was an eminently practical man, and as such had done exceptional service for the Association both in his capacity as Branch President and as a member of the Council of the parent Association. Mr. Horne, on the other hand, was a gentleman of highly scientific attainments, who would in his turn link up the practical side of their work with the scientific.

The proposal was carried unanimously and with acclamation, and Mr. Oswald vacated the chair for his successor.

Mr. Horne, in acknowledging his election, said he would endeavour to follow in the footsteps of his predecessor and carry on the work he had so well begun. He (the speaker) was convinced that if science was not placed in touch with practice it was of little value. He himself endeavoured to look at science from a practical standpoint. In conclusion he moved that the members express their appreciation of the work done by Mr. Oswald during his term of office.

Mr. Woods seconded the motion, which was carried with applause.

Mr. Oswald, in acknowledging the motion, referred to the work of the honorary secretary, Mr. T. Murphy, who, he said, had really borne the brunt of the labours in the past year. He (Mr. Oswald) had received all the credit, but Mr. Murphy had had all the hard work and the kicks. It was mainly to him that the thanks should be accorded.

Mr. T. Murphy modestly replied that Mr. Oswald was offering thanks which were really due to himself.

The next office to be filled was that of Vice-President, for which Mr. J. Ellis, of Messrs. George Kent, Limited, was proposed and unanimously elected.

The meeting then proceeded to the election of the Branch Council, and the following gentlemen were elected:—Messrs. C. T. Aston, R. Bennett, E. A. Chell, T. R. Creighton, G. B. Henderson, B. Sperring, R. Woods, A. Whiting, and G. Cunningham, all previous members of the Council; and Messrs. W. Ellis, H. O. Beere, and A. Willis new members.

Mr. Murphy was also re-elected Hon. Secretary, and the meeting closed.

Annual Convention of British Foundrymen's Association.

We are informed by the General Secretary of the British Foundrymen's Association, Mr. J. E. H. Allbut, Highfield Road, Stretford, Manchester, that the next Annual Convention of the Association will be held in the College Buildings, Cathays Park, Cardiff, on August 6, 7 and 8 next. Particulars of the Papers to be read, and other details of the arrangements will be published later.

* Journal of the Iron and Steel Institute, 1906 No. I, p. 28.

The Grading of Pig-Iron.

Before the West of Scotland Iron and Steel Institute on December 15 last, a discussion was held on "The Grading of Pig-iron." Mr. Walter Dixon (President) occupied the chair.

The SECRETARY read the following communication on the subject from Mr. Mayer, of Dumbarton:—

"I have every reason to believe that in the near future the British Foundrymen's Association will deal with this subject from the foundryman's point of view. There is no doubt that the foundryman has been patient and long suffering in putting up with and using metals of an inferior quality mainly owing to the modern methods of making pig-iron, whereby quality has to give way to quantity. The correct way to judge pig-irons is by analysis for all purposes—the steel makers and ingot-mould makers proved it and compelled it. Then, again, instead of the foundries being under Board of Trade and other inspections in making iron castings, it is the blast-furnace plants that should be supervised by the Board of Trade.

MR. W. P. BROWN said that, with regard to Mr. Mayer's suggestion of the Board of Trade coming into the question, he thought it more in their line to look to the weight than to the grade. So far as he was concerned, he had been quite able to satisfy the Inspectors, who were a great deal more in touch with the founder than the Board of Trade people were likely to be. If the furnace did not make the grade that the foundryman wanted, they had just to take what they could get; but he found a great difficulty, when he got an order, in knowing what was actually wanted. No. 3 or a No. 1, or a No. 3 soft, or something of that sort would be stipulated, but there were as many kinds as there were single letters in the alphabet. He thought the blast-furnace man would be able to meet the requirements of the foundryman when the latter could say exactly what it was he wanted.

PROFESSOR A. CAMPION said that the first thing to be decided was—what was meant by the grade of iron? Did the grade mean that the iron was of a certain composition, or did it simply indicate a certain fracture appearance, or did it mean a combination of these? It had in the past been considered that iron having a particular fracture appearance would have a definite composition, but under modern conditions of hard driving and rapid working in the furnace it was practically impossible to ensure that pig-irons having a certain fracture appearance would have the same composition in all cases. That appeared to indicate that grading of iron could not be done by fracture alone, or by analysis, but by a combination of the two. They might, for instance, have a No. 1 fracture and the composition that of a hard No. 4, and a No. 4 fracture and the composition that of No. 1, so, therefore, it was impossible to take either one or the other by itself. This question of grading was becoming of more importance to the foundryman, who was beginning to wake up and take a greater interest in his work and getting to know more about what he wanted. The foundryman had been compelled to consider this matter owing to the very varying results obtained from the different qualities of iron with which he had to deal, and the unreliability of the fracture appearance. The very fact of his being compelled to enquire into the matter had perhaps led him to go to the other extreme, grading by analysis, believing that if he used iron of a certain composition he was bound to get what he wanted in his cast. But in this he has been disappointed, owing to the fact that he omitted to take into consideration the changes occurring during remelting and the influence of mass. The composition and condition of constituents of the iron and the properties of the casting were not necessarily the same as with the iron as charged into the cupola. The foundryman did not make sufficient allowance for his treatment, or of the changes caused by the method of melting. He might blow too hard, melt too hot, or cool too slowly. The rate of cooling was perhaps the principal factor, and it depended very largely on what the composition of the iron was as to what the correct rate of cooling should be in order to get the desired properties in the finished casting. With high-silicon iron cooling should be very much quicker, in order to obtain the same properties as given by iron low in silicon cooled more slowly. Silicon assisted in precipitating the carbon in the graphitic condition, and it also increased the range of temperature through which graphite could separate from the iron. Both actions took place during the cooling of the metal, so that the foundryman had to consider not only the composition required under a certain standard rate of cooling, but what would be the rate and condition of cooling of the metal after he had cast it. In connection with this subject a great many factors had to be considered, not only temperature, time, and composition, but the type of mould, and the number of chills put in. All had a considerable influence on the final properties, and also to a certain extent on the composition of the iron. What should be aimed at was to have a standard of what was meant by the grade of iron, whether a particular composition or a particular appearance of fracture. The grading of iron had always been an arbitrary system, and every one fixed his own standard. That was one of the great difficulties of grading by fracture, it was really only a relative method. One man rejected, and wouldn't have at any price, an iron which another man accepted, and said it was just what he wanted.

Continuing, the speaker said that cast iron was probably one of the most complex materials with which the engineer or the metallurgist had to deal. They were not dealing with a definite compound or with a simple mechanical mixture, but with complex mixtures of chemical compounds with mechanical mixtures. The question of the different forms of graphite and also the different properties obtained was one which was undergoing investigation at the present time by one of the other members of the Institute and himself, and they hoped shortly to publish the results of their investigations. He advocated grading not by fracture alone, nor by analysis alone, but by a combination of the two; and it was also desirable, he thought, to get some approximate idea of the mechanical properties of the material they were dealing with, which could be done in many cases by simply noting the way in which the pig fractured. They should also, he thought, have a standard method of taking samples.

MR. A. B. MARQUAND said that regarding foundrymen buying their iron by fracture, it was well known that a portion of a cast would be sold as No. 1 and a portion of the same cast sold as No. 3. It was a difficult thing for an ordinary individual to understand why there should be such variation in price in the same cast. There seemed to be some reason for the foundryman paying a higher price for one quality of iron from a cast than for another quality

of iron from the same cast, and that always seemed to him to point to there being something in the grading of iron from the foundryman's standpoint.

Professor A. Campion said that when the foundryman paid a higher price for one portion of the iron than another from the same cast, he did so because they had different fractures and because he expected to get different results from them. As a matter of fact he wasted money, because when the iron was remelted and cast under normal conditions both portions would give the same result. It came back to grading, because in a No. 1 fracture he was only getting a different appearance for the same composition. The foundryman, in fact, pays a higher price for No. 1 in order to obtain a certain result, and then in the end finds his iron is perhaps No. 4 analysis, and the casting too hard and useless for the purpose for which it is intended.

Mr. Walter Buchanan said that from a practical and commercial point of view he thought it was very much to be desired that some much more settled system for the grading of iron should be resolved on, because at the present time in the British Isles they were confined to a very small number of grades, although in point of fact they were using several qualities in each of the No. 1, No. 3, and No. 4 grades. In America he understood there were something like 13 different grades—13 different steps altogether which the American foundryman used to express his idea of the quality of iron he desired. Here in this country they had unfortunately only two or three steps, and in each of these steps there were variations which entirely altered the quality of the iron the foundryman desired. Mr. Brown had told them that a man who ordered No. 3 pig-iron did not know what it was he wanted. They had, in fact, to discover the class of casting he was in the habit of producing, and also what proportion of scrap iron he was in the habit of using. Mr. Mayer suggested that the Board of Trade should settle down upon the blast-furnace plant rather than upon the founder, but that he thought was rather a side remark. The pig-iron manufacturer could make any quality of iron, and had his materials and his product ready for supplying to his customer all kinds of iron to his requirements, but it was the duty of the foundryman to say what it was he really did want—whether by fracture, by analysis, or by a combination of both. He thought that it should be a combination of both, but it lay with the foundryman to make up his mind what the particular quality of iron was that he required for his purposes. The foundryman ought to be educated sufficiently to know what he wanted from the maker, and he (the speaker) considered that the first essential was for every foundry to have a chemist on the premises able to guide the management.

Mr. James Love said he agreed with practically all that Mr. Buchanan had said, except his suggestion that they should have more grades than they had at present. He thought that to increase the number of grades until the grading was more strictly defined would only be adding to the confusion.

The President said that it appeared to him that the trouble and apparent inconvenience which were being experienced at the present time, not only by the makers but also by the users of pig-iron, were due in the main to the different conditions prevailing at the present day, as compared with those of say ten to twenty or more years ago. In the older and less scientific days, and the days of lower pressure both in blast furnaces and general engineering practice and when available material and working conditions were more constant than appears possible at the present day, the world seemed to get on very well with a rough-and-ready grading of pig.iron; the present were more scientific days, which meant days of more exactitude, and it seemed to him that these altered days and altered conditions called for a revisal of the basis on which pig-iron was both bough. and sold.

British Foundrymen's Association.

Annual Meeting of Birmingham Branch.

The proceedings of the Birmingham Branch of the British Foundrymen's Association on Saturday, May 11th, when the members met at the Municipal Technical School, included the annual business meeting. This was followed by the reading and discussion of a Paper by Mr. H. Pemberton (Derby) on "The Cupola and its Management," for which see page 362. Mr. H. L. Reason (President of the Branch) was in the Chair.

The Hon. Secretary (Mr. G. Hailstone) read the Report of the Council for the Session just concluding, in which it was stated that the membership of the Branch at the last annual meeting was:—Honorary Members 2, Members 12, Associate Members 83, Associates 97, Total 194. During the year there had been elected 4 Associate Members and 5 Associates, bringing the total membership of the Branch to 203.

On the motion of Mr. C. Heggie, seconded by Mr. C. Morgan, Mr. Reason was unanimously re-elected President of the Branch. The other officers were elected as follows: Senior Vice-President, Mr. C. Heggie (proposed by Mr. Reason and seconded by Mr. Toy); Junior Vice-President, Mr. H. Pemberton (proposed by Mr. C. Mace, and seconded by Mr. Robinson); Hon. Secretary and Treasurer, Mr. G. Hailstone (proposed by Mr. R. Buchanan, and seconded by Mr. W .Sheldon).

To form the Branch Council, all the old members still in the district were re-elected except Mr. F. J. Cook, who, on account of the pressure of exceptional work as a member of the Central Council, had been unable during the year to make the qualifying number of attendances. Messrs. Morgan, Baugh, and Sutton were added to the Branch Council, which is now constituted as follows:—Messrs. Buchanan, Bullock, Dalrymple, Howell, Jacques, Robinson, Toy, Morgan, Baugh and Sutton.

It had been suggested that the Branch should have an outing on a Saturday afternoon in June, and the Council proposed that the members should take train to Droitwich and drive from there through Ombersley and Holt Fleet to Witley Court, one of the seats of the Earl of Dudley. After some discussion it was decided to leave the matter in the hands of the Council.

Speaking recently on the question of the effects on crucibles, respectively, of gas and coke, Mr. M'Ghee, the Superintendent of the Glasgow Gas-Fitting Department, mentioned that, from the practical experience of one firm who had tried both systems, for every three crucibles destroyed in the gas-heated furnace, five were put out of action in the old system. During the same discussion it was stated by one speaker, in regard to the bursting of crucibles in gas furnaces, that there was little difficulty in putting the furnace right should the crucible burst, as the metal simply ran to the removable bottom of the furnace, and the apparatus could be put right again in about five minutes.

Modern Foundry Practice.

Lecture before Newcastle Foundrymen.

Before the monthly meeting of the Newcastle-upon-Tyne and District Branch of the British Foundrymen's Association, held on April 27, the Branch-President, Mr. R. Wallis, in the chair, Mr. James Smith, of South Shields, presented a paper on "Modern Foundry Practice." The Paper was illustrated by lantern slides.

The lecturer gave a general outline of the history of foundry work from the time of Tubal Cain. He said that in reading the history of castings he was many a time struck with wonder as to how the ancients made the work, melted the iron and lifted the huge castings made. Their foundry trade was a very old one, and it was very interesting to find that hundreds of years ago castings were made which it would be impossible to make now except in a foundry specially constructed for them.

Dealing with bad castings, the lecturer said that a great many engineers held that there ought to be no bad castings, but very few men had come forward to show how to make good castings. He ventured to point out, and with pardonable pride, that considering the causes of bad castings, very few were spoilt. Engineers did not hold moulders in the highest esteem; he thought the reason must be their want of knowledge of the difficulties a moulder had to contend with, and of the full importance of his work. He also commented on the fact that incompetent persons were sometimes appointed to examine castings, with occasionally the power to condemn them. A lad would go to be an engineer, spend a few months in all the different shops—excepting the foundry—and finish off at the drawing office; but what pretensions such a youth could have to a knowledge of how to examine castings, and how he could be able to converse about moulds and the make of them, was not quite apparent; yet it was to such persons, in many cases, the inspection of castings was entrusted, the moulder thereby suffering. It was sometimes laid to the charge of moulders, or rather, the foreman, that they hid the faults of castings. Although he strongly condemned this practice in all cases, there was perhaps a slight excuse for their doing so when they knew that they were to be overlooked by incompetent persons who would make a lot of trouble about a mark on the surface through sheer ignorance of its real nature and cause, but which mark affected the casting only in appearance. There was a very small percentage of bad castings made, considering the nature of the material a moulder had to work with, and he ventured to say—he did not say it about all, but about some—that if engine builders were to make their own castings the percentage would be even less.

As regards specific pieces of work the lecturer first dealt with the making of a ship's propeller, and then with a cylinder, commonly called an upside-down cylinder. Usually, he said, cylinders were made with the crown up, but there were two or three firms in that district who believed in having sound castings in the crown, and had the cylinders made with the crown down, casting a head on the top. The most important part about making the cylinder illustrated was the commencement of it, and if it was not started properly, he was quite sure it would never be finished. In many places on the North-East Coast the cylinder would be run down the bore, but on the example shown it was run down the chest, and the chest only. His experience was that that gave a far better cylinder; he had run cylinders in this way up to 14 tons weight, having adopted the method five or six years ago.

The lecturer then showed several very interesting views of burning-on to repair castings, such as a broken tip of a propeller blade. In such work the formation of the casting had to be considered, as well as the kind of metal to be used. It was not every casting that would stand a portion of it being brought to a melting heat without suffering in some part; it depended almost entirely upon the formation. When the casting was a bad one, owing to fracture or other cause, a moulder thought it could not be made worse by burning. Burning or mending a casting could only be done once on the same place, hence the necessity for taking every precaution before beginning. It might be asked whether a burn was as good as if the casting had never been burnt. He would reply that providing the mend had been properly done, and there were no symptoms of fracture of the casting, it was as good as if no burn had taken place.

Dealing with foundry management, the lecturer said that the person who had control over a foundry ought to possess many qualifications. First, he should be able to manage and control men; he ought to be thoroughly conversant with the work in all its branches which had to be carried on under his direction; he ought to be a sober man; he ought always to be able and ready to at once assist anyone who had got into difficulties with his work, providing such difficulties had arisen from error of judgment; he should show no partiality and no favour, treating every workman alike. He should have a mind of his own, and yet not be above taking a hint even from a labourer. The foreman's position in a foundry was not a bed of roses, but he should try and show a cheerful face, although one minute he might feel full of smiles and the next minute be down in the mud.

Discussion.

The CHAIRMAN said Mr. Smith's Paper and the views he had shown dealt with every-day difficulties in the operations of ordinary foundry work. Some of them had been rather out of the usual run, for instance, the moulding of a cylinder with its bottom down was not a usual method in that district. He was struck by the method adopted for venting the mould in the case of moulding of a cylinder with its feet at the bottom. He noticed that venting through the bottom was provided to a great extent. He would like Mr. Smith to give them a word or two on the venting of such a mould as that cylinder. Venting, from a moulder's point of view, was one of the most important points in avoiding defective castings. From an engineering point of view the propeller shown was in the first place rather a novelty, and, apart from the question of foundry work, it was a very debatable point as to whether a propeller with a varying pitch of which there was not 6 in. the same pitch, a varying pitch from root to tip and from forward to aft, was as efficient as one with a constant pitch, and raked off from the centre of the boss to the tip. He believed it was recognised now that a propeller with a constant pitch from root to tip and forward to aft, provided the propeller blade was laid back sufficiently, was the most efficient blade. Bad castings, as a rule, were

caused either through inexperience or carelessness. The burning of castings was a matter which ought to be gone into with a certain amount of discretion and common-sense. He had seen some remarkably fine pieces of work in that direction.

Mr. Davison said he did not think the present system of burning castings could be improved on very much; nearly everyone had the same method, although he, Mr. Davison, instead of making a sand burn, moulded off one of the good blades, thereby getting a better pitch and the right thickness.

Mr. Smith, in replying, said he would not ask a man to depart from his own method of turning out good work because he had heard him (the speaker) say he liked to run cylinders in a certain way; but he had always found his method to give him completely successful results. He used to run the cylinders down the bore, but he was very much against that method now, although it took him some considerable time before he was satisfied that running them down the chest was the better way.

Mr. Henderson desired to know the lecturer's opinion of dry-sand moulding as against loam moulding; did he consider them equal? With regard to the repairing of castings, his experience was that in small work oxygen welding was more successful than burning. He thought the reason for the welding being more successful was that more pains were taken in heating up the casting thoroughly before beginning and also with regard to the cooling of it; probably also there was used in such cases an iron richer in silicon than the foundryman used.

Mr. Smith, in reply, said he thought that the more exact castings could be made in loam, meaning by exact, of course, more to the pattern. He did not think the skin would be any better, but the casting would be more correct in size. On the point of dry sand or green sand, he thought that in a proper green-sand foundry he would say make the castings in green sand; but in a foundry where the sand was mixed the most advisable thing to do was to make them in dry sand, because the percentage of waste from the rough, close sand was greater than a proper green-sand job.

The meeting concluded with a vote of thanks to the reader of the Paper.

Electric Arc Welding for Steel Castings.*

By B. M. Bowers.

Electric arc welding is the fusion of two metals by electrical means, simply by allowing them to melt, then to mix and unite as they cool. This method of welding should be regarded as a trade, as it can only be acquired by careful study and gradual development from simple to difficult jobs. The operator should understand the expansion and contraction of the metal he is about to weld, and use a hammer freely, in order to relieve any strain occurring in the casting by the sudden heating of the arc. This is undoubtedly the secret of a high tensile strength in a weld, rather than the material melted into the defect. Blacksmiths usually make good electric welders, which is probably due to their experience with fire welds, the heat treatment of tools, etc.

The low cost and rapidity with which this process can be applied place it first among methods of repairing defects in castings. The possibilities of this process in repairing blow holes, sand spots and checks, welding on lugs and burning off fins, gates and risers, have resulted in saving many castings which would otherwise have been condemned.

Too much confidence should not be placed in the process, as it must be remembered that electric welding is equal only to about 60 per cent. of the original strength. In one or two instances, 85 and 90 per cent. efficiency has been obtained, but this could not be repeated, as a rule, and, therefore, should be considered as possible but not probable at all times. Nevertheless, the writer believes that with careful study and further investigation it will be possible to attain 100 per cent. or more of the original strength.

The real cause for this low efficiency appears to be oxidation, caused by the excessive heat of the arc. This is somewhat reduced by the use of the metallic electrode, which reduces the amount of current; but as this method is very slow and hard to master, it would not be advisable to recommend it for general foundry use.

A simple electric welding apparatus, which is easily constructed at little cost and serves well, consists of a rain barrel or suitable tank, two steel plates, carbon or electrode holder, and enough flexible cable to connect up. The steel plates are suspended in the barrel or tank, into which a proper amount of water impregnated with common salt has been placed. One plate is connected directly to the negative side of a direct-current line, ranging in voltage from 110 to 550, while the carbon or electrode holder is connected to the other plate, with a flexible cable of suitable length, to allow free manipulation of the electrode.

The casting or pieces to be welded should be grounded or connected to the positive side of the line. By adjusting the steel plates submerged in the bath, a current of almost any amperage can be obtained.

Next in construction is the carbon electrode. A piece of $\frac{3}{4}$-in. wrought-iron pipe, 18 in. long, is threaded at one end to carry a $\frac{3}{4}$-in. socket. Into this socket a pair of steel clamps are placed to hold an arc carbon 1 in. in diameter and 6 in. long, tapered to a point.

The clamps holding the carbon are firmly secured in the socket by several light taps of the hammer. A wooden handle is then made to fit over the pipe, near the centre, to protect the operator from shock and heat. At the other end of the pipe, two $\frac{1}{4}$-in. holes are drilled and tapped, about $\frac{3}{4}$ in. from the end and $\frac{3}{4}$ in. apart, to hold the negative terminal wire. Above all, the operator must protect his eyes and skin by wearing a mask or hood over his head, made of canvas, tin or aluminium, with an eye-piece, containing suitable coloured glass. About two pieces of each colour are sufficient. The eye-piece may be 6 in. long and 2 in. wide and extend about 1 in. from the mask. Care should be taken that the brightness of the arc does not strike the operator's eyes or face, as such rays produce painful irritations. The operator should also protect his hands and wrist by wearing gauntlet gloves of pig-skin or buck-skin. Next, the operator must have a material to weld with, which for steel castings must

* Abstract of Paper read before the Associated Foundry Foremen of Philadelphia, March 12.

be a soft steel wire, about 5/16 in. in diameter, and to be from 0.07 to 0.10 carbon.

Bringing the carbon electrode in contact with the metal to be welded and instantly withdrawing it to a distance produces the hottest flame known, by which the metal can either be fused, moulded or melted away entirely, as desired. While the arc is drawn, the welding material is fed in slowly. Vigorous hammering should accompany each weld.

Probably the greatest difficulty experienced in electric welding is the prevention of chilled welds, ordinarily known as hard welds. This trouble is due to the sudden chilling of the metal and at times affords difficulty in machining or filing. To avert this trouble the operator, before melting any metal should allow the arc to play on the spot to be welded for a few seconds, so as to pre-heat the surrounding metal, thus storing a certain amount of heat in the casting to be welded, which, when finished, will cool off more slowly.

Blow-holes are usually clean and free from sand, and submit to welding easily. Sand spots must be thoroughly cleaned and all foreign matter removed before starting to weld. Checks or cracks in castings should be burned out, by tilting the casting and applying the arc, allowing all melted metal to run off by gravity. After they are burned out to the depth of the check, they should be reheated in a forge fire, expanding the check to its maximum, then, while red-hot, welded quickly and hammered while cooling.

For burning off scabs, fins, gates or risers, a current from about 400 to 500 amperes should be used, if any speed is desired. With the above amperage, a riser 4½ in. square can be cut off flush in less than five minutes. The arc carbons should be pointed, thus concentrating the flame to a small point, which is very essential for either welding or cutting away metal.

All castings of any importance should be preheated in a suitable forge or fire, and welded while red-hot, and not allowed to come in contact with any drafts, rain or moisture, as this often causes hard welds.

Reheating the castings after being welded is detrimental, as it forms minute checks throughout the weld. This has been proved by the microscope.

The arc should be as long as possible, as the excessive heat is, no doubt, the cause of the pronounced oxidation so common in welds. It is only reasonable to assume that if the temperature of the arc were reduced, the oxidation would also be reduced accordingly. This can only be accomplished by drawing the arc to very near the breaking point. A reduction in amperes would not reduce the temperature but simplify the volume, the temperature remaining the same.

The welds should be made with the least possible number of applications of the arc. The arc should be given a rotary motion of the hand, so as to heat as large an area as possible, instead of concentrating it to one spot, which crystallises the metal, leaving it hard and brittle. At times a suitable flux is essential. The theory in connection with its use is that any carbon which may have been introduced into the weld, from the carbon electrode, will unite with the oxygen in the flux, to form a carbonic gas, leaving pure iron. If, however, this gas is not eliminated, it will cause sponginess in the metal.

The most common flux is borax. The use of borax simply tends to prevent oxidation by excluding the air. Better results will be obtained if the water of crystallisation, of which borax contains nearly 50 per cent., is first removed. This can be done by melting the borax in a graphite crucible until it is free from bubbles, then pouring it out, allowing it to cool, and finally pulverising it.

When welding brass or bronze, the metal must be supported in such a manner that the shape will be retained. The arc should be applied at a low voltage, and for a very short space of time; otherwise these metals, on account of their comparatively low fusing points, would be melted away.

The metallic electrode which has been previously mentioned can be used on thin cross sections, where tensile strength is essential.

Blowholes in Rope Pulleys caused through the Splitting Plates or Cores.

By F. Hardy.

The writer would like to draw attention to this important question, as there is sometimes trouble experienced with the splitting plates or cores in some shops, owing to them blowing, and the air not getting away, resulting from the splitting plate or core being almost covered with metal. Take first the splitting core which is entirely made of sand, with irons in to bind it together, and which, when being made by the coremaker, will certainly have vents in. (The writer is referring now to cores anything from 6 in. by 3 in. up to 18 in. by 6 in., and about ½ in. thick.) The air off these cores should by all means be brought away, and a good way is to put a piece of string in each vent and then make up well on either side of core with a little wet sand, carry the vent well away from the mould, then pull out the string and fill up with fine cinders. Certain constituents of the sand when burning will want to get away, and if they cannot get through the vents will make a road through the metal and keep on blowing till the wheel finally sets.

Some of the trouble is connected with the bolting cores that go through the splitting cores not touching the sides of the mould; these cores should fit very tight, and care should be taken that no metal gets over the ends of these bolt cores, or the air will force its way through the mould. Some shops have prints for the bolt cores to fit into, and then there is no difficulty in fetching off a vent. There should be about 1 in. of print at either side for the core to fit into, and then the moulder can make up over the core. The writer likes the prints on, as a better job can be made of the mould, through having the cores secure. The air off the bolt cores in the boss of the wheel can be brought off with a few fine cinders, as above.

Consider now splitting plates which are made of iron or steel, and which will vary in thickness according to size of wheel. The plates will have to be made in the smithy and cut to a template. The best and most successful way to prepare splitting plates is to give one side a coating with thick core gum or clay wash, and then daub on some fine sieved loam, and when dry do other side same; then rub to the required thickness which will be about ⅜ or ½ in., with a flat board. It will not be possible to get any vents in these, as the plate will be in the way, and there will only be about ⅛ or 3/16 in. of loam on either side of it; but the molten metal will burn the material in the loam owing to there only being a thin layer on the plate, and the gases generated will come off while the wheel is being cast. Instead of using blacking it is better to tar the splitting plates while they are hot, and see that the spikes that hold the plates in position are tarred also.

A point in favour of the splitting plate is that it is easier to handle, being all one piece of iron or steel. It is not apt to buckle, and can be used again if more than one casting is wanted.

An Unusual Operation in Chilling.

By Francis W. Shaw.

In addition to its uses in counteracting shrinkage effects and in closing up the grain of castings, chilling is often resorted to as a means of saving machining. Many examples of its use in this connection are to be found in the castings used in textile machinery. An interesting piece of work is that shown in the accompanying drawings.

Fig. 1 shows in section the sliding jaw of a bench vise of the "sudden-grip" class. The half nut in this case had to be arranged to pass the lug containing the left-hand end of the screw. As a consequence the end of the screw became too weak to resist the lifting stress. To remedy this a half bearing was interposed to render possible some increase in the strength of the screw. This is shown clearly in Fig. 1. In order to cheapen the cost of production it was decided to resort to chilling the screw bearings, the supplementary half bearing, and the faces of the front lug against which the screw head and retaining collar rotated.

To this end the pattern was made as shown in Fig. 2, and in halves to facilitate moulding, the quantities required being large. (Note the prints which are arranged to support the chill, and the dust guard intended to prevent the admission of dust to the screw front bearing.)

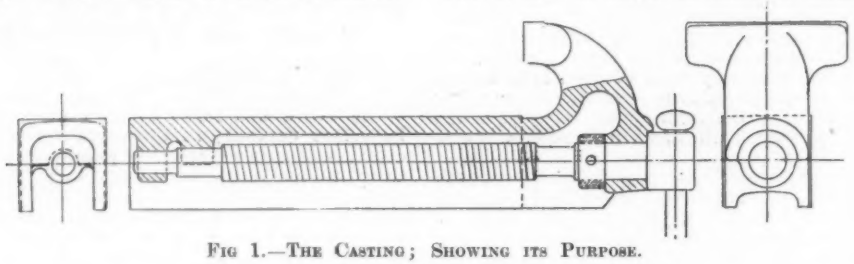


Fig 1.—The Casting; Showing its Purpose.

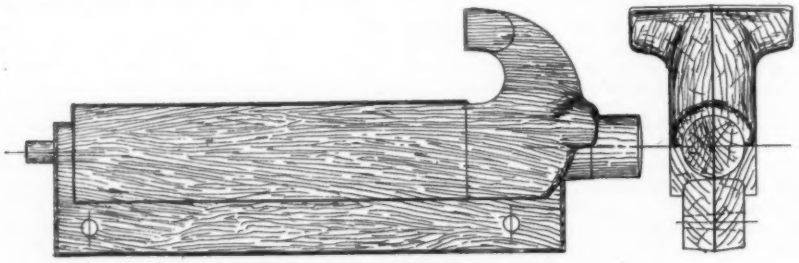


Fig. 2.—The Pattern in Halves.

Fig. 3 shows the construction of one-half of the core box. The loose piece, arranged to slide out endwise, was, of course, necessary to nullify the undercut caused by the compelled shape of the small left-hand lug. The chill, having a loose collar intended to chill the portion of the front lug to receive the retaining collar shown in Fig. 1, was placed before ramming in the core box in the manner shown. After ramming the sand was struck off level by means of the strickle shown in the end view. This

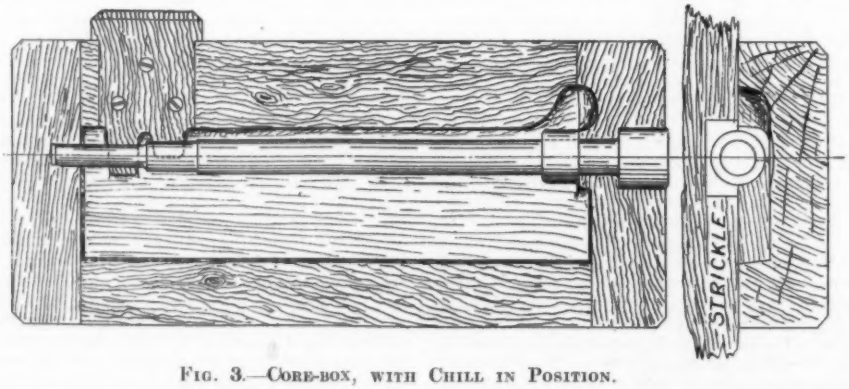


Fig. 3.—Core-box, with Chill in Position.

strickle had a portion cut away as shown to clear the chill. The same chill was used for the corresponding half of the core. Sufficient chills were furnished—all uniform—to supply the requirements in the way of output, varying from six to twelve, according to the size of the vise. It will be noted that the parts of the chills which form the screw bearings are slightly tapered to facilitate withdrawal after casting. The half cores were not fixed together, but each put into its own half of the mould. The whole (joint) of the mould and core.

Fig. 4 is a section through the completed mould at the chill. Before finally closing up to mould the chills were coated with plumbago in the form of a paste, and well dried to avoid possibilities of blown holes from a damp chill.

It was found necessary to replace the chills at intervals, constant use resulting in a reduction of diameter at the parts forming the bearings, each chill lasting for between 100 and 150 castings. A

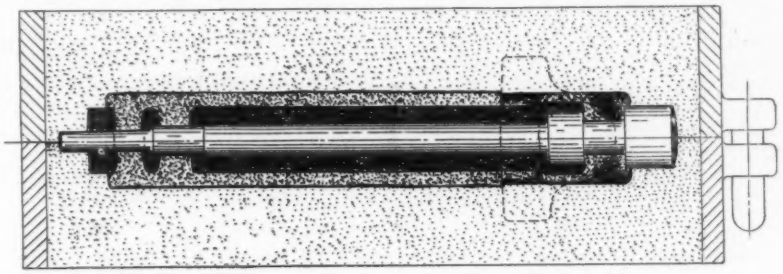


FIG. 4.—SECTION OF COMPLETED MOULD AT CHILL.

of the patterns and coreboxes were made sufficiently accurate to make it impossible to have a crush or a flash between the half cores. Levelness was checked by means of a straightedge passed over the surface special gauge, having its essential parts a shade larger in diameter than the same parts of the screw, was provided as a check against allowing the chills to become too small.

Making Open-Cast Iron Pulleys.

By A. Martin.

The method of moulding for cast-iron pulleys about to be described is adaptable to pulleys of any diameter. The writer has used different methods, such as lifting the top half with gaggers and with separate lifting plates between each arm and bolting to top part, in the case of patterns with fast arms; but the following is the method most up-to-date. A 20-in. pulley may be taken as an example.

The rim pattern should be separate from the arms, accurately turned inside and outside, and the same thickness top and bottom. The most useful depth is 10 in., for if a pulley is wanted 8 in. deep the extra 2 in. can be cut off in the machine shop and ensures a sounder casting; while if it is wanted 20 in. deep it can be drawn about 3 in. at a time until the required depth is reached, with very little trouble. Three holes are necessary, about ½ in. from top of the rim, for the drawing hooks.

Arm Pattern.

In Fig. 1 is shown the arm pattern, which is of the S design, with a flange of metal all round between the arms, generally termed a beading. There is a 2-in. hole in the centre, bored true, for the bosses to fit in. These should be made of wood and allowed to fit easy. Two-inch washers with three holes in to allow them to be screwed on the boss, one on each half, form the best device for ensuring the correct fitting of the boss into the hole in the centre of the arm pattern. Two ½-in. holes are necessary in two arms opposite each other in small patterns, and three in larger patterns, equally divided, for the drawing irons to fit in.

Lifting Plate.

Fig. 2 shows the lifting plate made in one piece, to lift the top half off the arms. This is made by ramming up on a bed a top part of the desired size, staking and lifting off. The arm pattern is put on the bed, and the shape marked by drawing the trowel or cleaner around the inside and outside of the pattern. The pattern is lifted off and two circles, one 2½ in. from the inside of the arms and the second one 2½ in. further out, are marked. The sand is cut from between these two circles, 2½ in. deep, care being taken not to obliterate the marks outside the two circles. A wooden pattern, ⅞ in. thick, will now be necessary, that will fit between two arms and allow ⅝ in. clearance all round, with a 1-in. bevel running all round. This is placed between two arms on the bed, broad side up, and filled around with sand, the same being done all round until finished. In the thick ring of metal six pieces of core, 1¼ in. thick, and wide enough to allow ⅝ in. clearance each side of the arm, will have to be fixed where the arm comes, level with the top. If a split pulley, two pieces of core should be placed in the plate where the splitting blocks will come. When the top part has been tried on, a wooden round peg, 2 in. at top, and ½ in. at bottom, and 2½ in. long, should be bedded in the top part where the centre of three plates comes; this allows the top half of a pulley when put back again to go in its proper place without any trouble. When cast the plate should be sent to the machine shop to be tapped and screwed in two places on the thick ring of metal, to allow screw hooks to be screwed in for lifting purposes. In large pulleys three wrought-iron staples are cast in to allow lifting with the crane. When one has been made this way any others that are required for the same size can be made off it.

Cope.

An outside cope, about 12 in. deep and ¾ in. thick, is necessary, and should be 6 in. larger than the pulley to allow 3 in. of sand all round the outside

of the rim. Two ears, 12 in. long, and projecting out from the cope 3 in., should be cast on. When the cope is used it is placed ears down; these are to stop the cope from being disturbed when getting the casting up. The cope is placed 6 in. in the floor, leaving 6 in. above the floor to stop sand from being kicked into the mould by persons passing, and it is levelled and rammed well outside so that it will become a fixture. Any depth of pulley can be made in this cope, being free from bars at the bottom, which are not necessary.

Moulding.

When the cope is set in the floor, the rim pattern is placed in to come ½ in. above the top of the cope, and rammed in the usual way, using black sand inside and outside of the pattern. The only facing sand used is on the arms and boss. If the casting is to be 8 in. deep, the arms are set the right distance from the bottom of the rim, the sand cleared off the top of the arms, and the lifting plate placed in and knocked down until it is bedded half way down the arms; the plate is then lifted out, and the little sand left around the arms is cleared, and parting sand dusted on. The lifting plate is wetted with water or clay-wash, and placed back again with the pegs in the same holes; the facing sand is sieved on, and sand tucked under the plate where the arms come, the plate being knocked down again to ensure a proper bed, leaving the lifting hooks in the plate and ramming up to the top, placing a runner peg on the boss.

The mould is then strickled off with a straight edge, and a runner bush put on, sinking about 2 in. below top of rim to allow of metal being in when the rim is run up. The rim pattern is drawn out, and a bar placed through the lifting hooks, when two men can lift off the middle and place each end of the bar on trestles. The boss is rapped and drawn down from underneath. A fillet is put around edge of boss, a camel-hair brush run around the outside edge of the arms, and the top half is finished. With proper ramming it needs no blacking on the top half. The arms are drawn out of bottom, the boss is filletted, and the camel-hair brush run round the outside edge of the arms to draw loose bits of sand off. It is then necessary to dust with blacking, use the camel-hair brush again, place a core in the centre the correct length—a trifle longer, if anything, to ensure touching—cut two run-off places with the trowel at the top of the rim, place the top half back again, and put on a plate about 1 in. thick and 2 in. less all round than the pulley, and with a hole in the centre plenty big enough to clear the runner bush on top of the middle, two staples being necessary for lifting it on. The weights can be put on this plate.

A bottom smoother should be run around the bottom of the pulley now. This is best done just before casting, when all the pulley bottoms can be done at once. The pulley as described is 2 in. deeper than the finished pulley has to be, but that ensures a sound rim, and being cast open allows gases to escape that would otherwise get in the casting. When cast a swab is run around the rim so that a feeding rod can be placed in the boss without forcing the metal through the rim. All pulleys should have extra cast on the top half of the rim, as it entails little work in an up-to-date machine shop to cut it off. No strengthening irons or gaggers are necessary when pulleys are made this way, which is the quickest, cheapest and soundest method of moulding by hand, one man being able to produce in a 10 hours' casting day, eight 20-in. pulleys, 10 in. deep.

Fig. 1.—Arm Pattern.

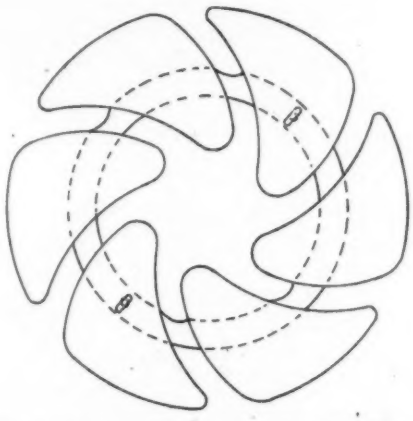


Fig. 2.—Lifting Plate with Lifting Hooks.

German Foundrymen's Association.

On May 29 to the 2nd of this month the German Foundrymen's Association held their annual convention in Berlin. The programme included a visit to the iron and brass foundries of the Siemens-Schuckert-Werke, while the following is the list of Papers presented before the meetings:—

"Improvements in Foundry Working," by Prof. Dr. Ing. A. Nachtweh, of Hannover; "American Foundry Methods," by C. Humperdinck, of Durlach; "Modern Conveying and Lifting Appliances in Iron Foundries," by H. Hermanns, of Duisberg; "New Simplified Procedure in the Art Foundry," by Max Küller, of Berlin; "Advantages and Deficiencies of the Bonvillain Moulding System, and its Latest Developments," by Arthur Lentz, of Düsseldorf; "The Rusting of Foundry Irons," by Prof. Dr. Arndt, of Berlin; "Concerning Small Bessemer Plants," by Carl P. Lavall, of Magdeburg; "The Study of Moulding Sand," by I. Holicky, of Blankenburg; "Concerning Management Economies and Improvements in the Metal Foundry," by C. Hunger, of Berlin; "The Advantages of German Foundry Machinery Compared with French and American Systems," by K. Axmann, of Cologne.

Melting Finely Divided Scrap Brass, Etc.

By Walter J. May.

In the ordinary working of the machine shop, large quantities of brass and bronze borings, turnings, and the like are produced, and needless to say these should be kept separate. Owing to the supposed inevitable great loss in melting, this small stuff is less carefully saved than the larger scrap, but really it should be kept clean and every possible particle should be collected and placed in bins kept for brass and bronze respectively. Iron should not be in the bins, and where the working necessitates the mixing of iron with the brass or bronze, the fine waste should be magnetted prior to being placed in the storage bins. All metal placed into store should, of course, be quite dry.

So far as possible the metal should be kept from full exposure to the air, and especially moist air, because owing to its finely divided state it presents an abnormal amount of surface for oxidising, and although oxides are readily reduced to their metallic state under proper conditions, yet in the ordinary foundry they are simply waste products which are too often lost. Even with large scrap there is too often excessive waste, but with the small stuff in addition to the loss through oxidation there is also waste through bad heat management, and the not unusual spillage of part of the metal charged into the crucible after the metal already put in has melted and become molten. The actual melting loss in many cases is not abnormal, but the spillage waste is large, and as fine stuff dumped into a hot coke fire is practically a total loss, various methods have been adopted to minimise this as much as possible, the usual device adopted being that of a wrought-iron funnel having a discharge opening smaller than the diameter of the top of the crucible. From some cause or other, spillage often occurs with this arrangement, and while to some extent it may be said to be suitable for the purpose intended, there is yet large room for improvement. One thing the writer has seen tried was a loose conical top, the small end fitting just inside the mouth of the crucible, and this really answered with some firemen, but with others it was too expensive, owing to breakages, and is not now very readily obtained.

The manipulation of the heat of the furnace is also an important point, because it is quite possible to overheat and "burn" the metal, while it is equally possible to hold the metal so long at just below melting point that excessive oxidation takes place, and this is particularly important, as generally when the fire is kept low the reducing atmosphere in the furnace is reduced to the lowest point. Very few ordinary furnaces have really closely fitting covers, and unless a cover fits close air is drawn in over the top of the crucible, and not infrequently into it. Of course, everyone knows, or should know, that oxygen should only pass through the firebars in any natural-draught furnace, and that practically the whole should be consumed in promoting combustion of the fuel, but owing to the rough-and-ready construction of the ordinary furnace this cannot often be secured in actual practice. At the same time a careful fireman can do more in regard to the prevention of loss than is usually to be found in ordinary practice, and probably this often leads to the retention of the old form of furnace.

Generally speaking the better plan to adopt when melting finely-divided scrap is to place a few pounds of large scrap in the crucible, and then when this is melted to charge in the fine stuff in moderate lots, repeating from time to time as the metal becomes well melted. Usually this causes fairly rapid melting with a small loss. It is, however, quite an easy matter to melt fine stuff alone without the bath of molten metal at first if the fire is well under control, as the whole matter can then be made to depend on the skill of the operator. In all cases a layer of granulated charcoal should be over the metal, and the size of the grains may be from that of an ordinary pea to that of a hazel nut, finely ground charcoal not being so good for this work. Where there is a lot of dirt—oxide and other chemical dirt, not just dust and that sort of thing—a handful of perfectly dry plaster of Paris should be thrown in the bottom of the crucible before it is charged with metal, the plaster bringing up the dirt as it rises, the crucibles not being appreciably injured by this material. The use of salt and similar fluxing agents is likely to injure the crucibles, and for this reason should be avoided, but there are proprietary fluxes on the market which are harmless in this respect, although effective with the cleansing of the metal.

It is fairly generally recognised that finely divided scrap cannot be most profitably dealt with in small crucibles, and while with ordinary furnaces 200-lb. crucibles are about as large as can be handled safely, with the mechanical furnaces 400-lb., 600-lb., and 800-lb. or larger crucibles can be dealt with both safely and economically. With a well-designed tilting furnace with a crucible of the desired size firmly fixed in the furnace body, and the lifting and tilting operated mechanically, the whole of the metal can be poured out without trouble or waste, and at the rate desired. The draught in such a furnace is under perfect control so that the heat is thoroughly governed. Fuel costs are kept low with these furnaces, while there is no occasion to spill or waste either solid or molten metal. For the running down of scrap metal there can hardly be anything better, and if a 600-lb. or 800-lb. size be used, the composition of the ingots produced would be practically level, and re-melting to secure equality of colour or content would scarcely be necessary so far as ordinary scrap is concerned. In fact, in most cases direct casting could very well be done safely, so far as colour and content is concerned where dealing with the scrap made in one's own works. Even with purchased scrap, by a little care in sorting, very uniform results can be secured.

Generally, a works of any kind produces some particular form of metal, and the scrap from that metal is, as a rule, the same in composition over long periods; but some change in content of the alloy takes place during re-melting, particularly with finely divided material, this making it necessary that additions be made to maintain the average content. Probably the greatest loss occurs with zinc, although other metals lose more or less, and where fine scrap from aluminium bronzes has to be dealt with it will be found that a considerable loss of aluminium occurs, while what is probably worse, a lot of difficulty exists in getting the metal clear from sullage, which becomes almost inextricably caught in the body of the molten metal. Usually at certain temperatures metals clear themselves, owing to their fluid condition, but if this does not occur either plaster of Paris or chalk will clear off solids if properly used.

The Production of Small Steel Castings.

Neglecting malleable, semi-steel, and other kinds of castings masquerading under the good name of steel castings, there have been in the United States until recently only three processes for the manufacture of steel castings.

All specifications to date call for steel castings to be manufactured by one of the following processes :—Crucible process; Tropenas or similar processes; open-hearth process.

It is quite usual to divide commercial steel castings into three grades, viz., soft, medium, and hard. The chemical characteristics corresponding to these three grand divisions are in general as follows :—

	Soft.	Medium.	Hard.
Carbon	0.10-0.20	0.20-0.35	0.35-0.50
Manganese	0.20-0.85	0.20-0.85	0.20-0.85
Phosphorus, not over	0.05	0.05	0.05
Sulphur, not over ...	0.05	0.05	0.05
Silicon, not over ...	0.40	0.40	0.40

The corresponding physical characteristics when the steels are properly annealed are as follows :—

	Soft.	Medium.	Hard.
Tensile strength, minimum, in lbs. per sq. in.	55,000	65,000	80,000
Yield point, minimum, in lbs. per sq. in. ..	27,000	31,000	38,000
Elongation, per cent.	22	18	15
Reduction, per cent.	30	25	20
Bending test	120°	90°	slight

As a general proposition the essential characteristics of the majority of steel castings are as follows :—

(1) Castings well cleaned, secured by sand-blasting.

(2) Solid castings, secured by proper gates and heads.

(3) High yield point, approximating the ultimate strength, secured by soft or medium grade of castings.

(4) A good bending test, secured by soft or medium castings.

(5) Freedom from brittleness when cold, secured by low phosphorus.

Characteristics 1 and 2 are within the control of every foundry. Moreover, defects in these qualities can usually be detected by the consumer through surface inspection.

Qualities 3, 4 and 5 can only be determined by the consumer through laboratory tests, and, in the absence of such tests, by care in selecting the manufacturer and the process he uses.

Crucible-Steel Castings.

The manufacture of crucible-steel castings as practised in America is purely a melting process, requiring little or no technical knowledge, as is evidenced by the rapid, almost mushroom growth in the number of plants throughout the country and clearly shown in the records of the advertising pages of technical journals.

Crucible-steel castings are, as a rule, made from punchings purchased in the open market. Unless careful analysis is made of each and every lot bought, most varying results in the castings are apt to follow. In this process there is little or no change in the phosphorus and sulphur during the melting of the punchings. The percentages of silicon and manganese are more or less under the control of the melter. The increase in the percentages of carbon is the most serious drawback to this process; in general it increases about two-tenths of 1 per cent.

"Metallurgical and Chemical Engineering.

The average good crucible steel casting will analyse :—

Silicon	0.25 to 0.50
Manganese	0.40 to 0.80
Phosphorus	0.025 to 0.040
Sulphur...	0.030 to 0.040
Carbon	0.35 to 0.50

The percentage of carbon in the punchings may remain constant during the melting, if the raw material is melted most carefully in a clay or clay-lined pot. This is rarely or never done in commercial practice, owing to the added initial cost of the pots and the fact that they last for fewer heats than the regular graphite pots.

If punchings of the same analysis are melted in graphite pots, the resulting steel will vary from pot to pot, and will also vary when melted in the same pot, depending upon how often the pot is used.

The change that takes place is well illustrated by the following actual test, which was an effort to make low-carbon steel castings, the material charged in the pot being selected muck bar :—

	Muck bar.		Analysis of Casting.	
Silicon	0.21	Silicon	0.17
Manganese	0.40	Manganese	0.39
Phosphorus	0.264	Phosphorus	0.204
Sulphur	0.017	Sulphur	0.015
Carbon	0.09	Carbon	0.29

From what has preceded it is to be noted that commercial crucible steel castings (owing to high carbon content) come under the grade known as hard. They are usually difficult to machine and will stand little or no bending test. Due to the fact that the crucibles hold only 80 to 100 lbs. of metal, more or less variation in the chemical and physical qualities is bound to result in a given lot of castings. While one casting may possess the desired qualities, a similar casting poured from the succeeding pot may be far below the standard.

Many consumers of small steel castings have purchased them from the foundries using the crucible process, under the false impression that they compared in quality with "crucible steel," otherwise known as "tool steel."

Tropenas Steel Castings.

The Tropenas, like the crucible process, is a melting, rather than a refining, method for making steel.

Tropenas steel castings are made by first melting the material in a cupola and then changing it to steel by means of a converter. A typical charge for the cupola would consist of about 63 per cent. of pig-iron, 20 per cent. of steel or wrought scrap, and about 17 per cent. return scrap, that is to say, sink heads and gates from steel castings.

It is to be noted that the resulting product of the cupola comes more or less under the head of what is known to the trade as semi-steel. This semi-steel is tapped from the cupola into the converter, and by means of a blast of air the carbon, silicon, and manganese are burned out. Ferro-manganese, ferro-silicon or silicon spiegel are then added to give the desired amounts of carbon, manganese, and silicon.

The Tropenas process is essentially the old well-known Bessemer process under a new name and on a smaller scale. Its main claim to superiority over the latter is that the air for combustion is not blown through the metal but on the surface of it. Like the Bessemer, it is also inferior to the open-hearth process.

Without the most careful selection of coke for melting in the cupola, high-phosphorus and high-sulphur steel will result. Great care must be exercised in selecting and analysing the pig-iron used, as the phosphorus and sulphur therein are not removed. The failure or success of this method of making steel castings is largely dependent upon the skill of the particular melter in charge.

Steel made by this process has the valuable characteristic of being extremely fluid, owing to its high temperature. It is not, however, as well adpated to the making of small steel castings as the crucible process, because the metal must be taken from the converter and poured into the mould from ladles which are at a much lower temperature than the converter, whereas in the crucible process the steel is poured from the crucible in which it was melted.

The Tropenas process, as generally practised, overcomes the defects of the crucible process, in that the carbon is more or less under control and lower carbon steel can be made, but great and wide fluctuations may occur from day to day in the different plants in the percentages of phosphorus and sulphur.

Below are given the analyses of castings from two different plants :—

Silicon.	Manganese.	Phosphorus.	Sulphur.	Carbon.
0.41	0.29	0.052	0.050	0.26
0.24	0.71	0.100	0 013	0.32

As far as a commercial proposition is concerned, and as far as the day-in and day-out practice of making good steel castings is concerned, neither the crucible nor the Tropenas process seems to be exactly satisfactory. The majority of the purchasers of steel castings buy without the rigid requirements of specifications, because to meet the specifications the manufacturer generally exacts an increased price, and therefore it is this day-in and day-out practice in which the average customer is interested.

To the purchaser who requires soft or medium castings the crucible process holds out little hope, and in the Tropenas process the case is little, if any, more encouraging, because of the phosphorus and sulphur.

The quality of steel castings made by the open-hearth furnace is far superior to those made by either of the processes mentioned, but, owing to the difficulty in handling the product, it is not generally used in the making of small steel castings.

Electric Furnace Castings.

The electric furnace, like the automobile, came in with the century. In 1904 there were only four electric furnaces in Europe, whereas there are now over one hundred.

Unlike the automobile in this particular, however, while America produces the largest number, it is far behind Europe in the adoption of the electric furnace. Foreign automobiles are held at a premium in the United States, and many manufacturers have to go to Europe for materials which, they say, cannot be procured in similar quality in America.

An examination into Europe's metallurgical methods bears evidence to the fact that many crucible-steel plants have discarded and abandoned their crucible furnaces and installed electric furnaces. In the United States electric furnaces have been installed for the making of tool steel or refining steel made by the Bessemer and even the open-hearth process.

While electric furnaces require for their successful operation a chemical and physical laboratory and the best of technical knowledge, they do make good steel, starting with either hot or cold raw material of any composition, pig-iron, steel scrap, or even from iron ore. The secret of success is in the procuring of a high temperature, the absolute control of the percentages of the elements which go to make up good steel, and the fact that the bath of molten steel can rest a long time underneath a neutral slag, permitting the removal of any gases or included slag, and the proper co-ordination of these various factors.

Electric-furnace steel can be made with any carbon content, phosphorus can be reduced when desired to between 0.01 and 0.02 per cent., and sulphur can be kept within the same limits. In fact, as stated, all the elements are within absolute control, as the metal need not be tapped from the furnace until its chemical and physical character meet the wishes of the melter, and in turn correspond exactly with the specifications of the consumer.

Remelting Ferro-Manganese in the Electric Furnace.

In a recent Paper read before the German Ironmasters' Association, the author, MR. R. KORTEN, remarked that the practicability of remelting ferro-manganese in the electric furnace had been demonstrated by his experience with a Keller furnace, in which charges aggregating about 2,000 tons were run for a period of four months, during which time the magnesite lining of the hearth needed only occasional slight repairs, while the acid lining of the vault also remained in good condition. The best way to avoid loss of ferro-manganese by volatilisation was to work with low-tension current, short arcs, and a hearth of large superficial area, so as to ensure uniform heating all over, instead of concentrating the heat in a small area. The cost of remelting depended largely on the method of working. The furnace should not be larger than was sufficient to deal with the required quantity per twenty-four hours, or the cost of keeping the ferro-manganese hot would come out too high. Current could be economised by heating up the ferro-manganese to pale red heat beforehand, this heating being effected more economically in an ordinary furnace than in the electric furnace. A further saving could be effected by substituting a small quantity of silicon for a portion of the manganese : for instance, by using an alloy containing about 76 per cent. of manganese and 4 per cent. of silicon.

In the discussion which followed the reading of the Paper, a number of experiences with various kinds of electric furnace were recorded. With a three-ton Girod furnace at Oberhausen 18.5 tons of 75 per cent. ferro-manganese were melted in 54 hours, with a current of 45 volts and 5,000 amperes, the current consumption for the melting-down stage ranging from 881 to 911 units per ton of cold charge, whilst to maintain the charge at the requisite degree of superheat (viz., 1,270 deg. C.) for pouring 8 cwts. per hour, a current of 45-50 volts and 7,000-7,600 amperes was found necessary, the consumption being 918 units per ton. To prevent loss by volatilization the bath must be protected from oxidation by a basic slag rich in lime, the reducing action being facilitated by the addition of coke from the distillation of petroleum in retorts. By retaining the slag in the furnace when the ferro-manganese was poured, so that the amount of slag was reduced to 13-15 lbs. per ton of charge, a considerable saving of current was obtained. The total loss of ferro-manganese, in continuous working, was only 1 to 2 per cent. at most. The dolomite lining of the furnace did not suffer any greater corrosion than in running charges of steel.

The Cupola and Its Management.*

By H. Pemberton.

A cupola should be as simple as possible. A plain round one with a brick lining tapering from the charging door to about 18 in. above the tuyeres, with a taper of about ½ in. to the foot, is the best, as with such a form all the descending material has an opportunity of falling away from the lining. This avoids a great deal of rough usage to the lining, and neutralises one of the dangers of the material, when it becomes hot and expands, causing the cupola to scaffold. For cupolas 2 ft. and above in diameter it is necessary to contract the diameter from just above the top tuyeres. This is done with a view of obtaining perfect combustion of the fuel at the centre of the cupola. This contraction of the diameter may be continued to the bottom of the hearth if a receiver is used, but without the latter it is necessary to increase the diameter about 6 in. below the bottom tuyeres to the original size above the contracted area.

All cupolas should be made with a double row of tuyeres, the number being in proportion to the circumference. The number in the bottom row should equal circumference in inches divided by 18.84, and in the top row should equal circumference in inches divided by 31.41. The tuyere area should be 11 per cent., or one ninth, of the cross-sectional area at the melting zone, *i.e.*, where the tuyere openings enter the cupola. The distance of the tuyeres from the hearth should be about 2 ft. 6 in., and the height of the slag hole about 6 in. below the bottom tuyeres. The height of the cupola should be equal to six-and-one-half times the diameter at the melting zone. A cupola should be made with a drop bottom, as this affords the men repairing it better facilities for getting inside to do the work necessary. The bottom requires making good every day, and this is done by ramming spent sand, obtained from the foundry floor, to a depth of about 9 in. upon the iron plate. This is more than compensated for at the end of the day by being able to release the bottom and allow the surplus incandescent coke to fall on the foundry floor instead of having to rake it out from the brick bottom with long heavy bars and rakes.

The writer does not recommend receivers on cupolas, on account of the extra cost of upkeep. But this is a debatable question.

The Repairing of the Cupola.

The repairing of a cupola after it has had a hard day's run, will first be considered. If the interior is examined after a day's blowing it will be found that the lining has more or less departed from its original shape, especially in the region of the melting zone, which is just above the tuyeres. Here slight depressions will be found) resulting from the fusion of the firebricks) and also some slag adhering to the sides, chiefly near the tuyere openings. Before the cupola is again used the lining must be repaired by the attendant. He will first perform the operation of "chipping down," *i.e.*, chipping away as cleanly as possible the pieces of adhering slag. When this has been done the depressions must be made good with some refractory material such as ganister, the latter being least affected by the action of the limestone. The ganister is prepared by mixing it with a small quantity of water and working up with a shovel to the desired consistency, *i.e.*, rather stiff, but soft enough to adhere to the lining. Commencing right at the bottom of the brick lining in the hearth of the cupola a very thin layer of ganister is put on and made smooth with a brush. This layer should only be a few inches high, and just come above and below the sand bottom. When this has been rammed in very little mending is required in the hearth, except the slag hole. The latter should be firmly rammed up with ganister, and a hole bored through with a tube about 2½ in. to 3 in. diameter. This tube may be left in for a short time until the ganister has become firm, when the former may be withdrawn, leaving a nice clean hole. That portion of the cupola about the tuyere openings should be made good. The lining on the underside should recede slightly so as to make it appear as if the top or upperside were overhanging, thus preventing the molten iron from dropping into the tuyeres as it falls to the hearth. The repairing should be continued up to about 18 in. or 20 in. above the tuyeres, the depressions being filled up very firmly with ganister and smoothed out to the original size and shape. Portions of old cupola firebricks may be used with the ganister for filling up the depressions, if they are very deep.

Starting the Cupola.

On starting the cupola, after lighting the fire, it should be charged with coke to a depth of 18 in. above the top tuyeres. It is not necessary to weigh the coke, but the depth must be carefully measured, as to fill up to more than 18 in. would be waste of coke, and less than this amount might involve serious trouble. Under the latter conditions, the iron, as it is charged, would drop too near the tuyeres. This would decrease the depth of the bed, and consequently necessitate a start with a melting zone too low. The blast, instead of blowing into the fuel, would eventually blow into the iron, and the latter would become oxidised, resulting in a serious loss of iron. The metal melted would not be so hot, probably throughout the whole of the heat, as it would have been if we had commenced with a good bed of coke. It is, therefore, much better to burn coke than iron on the bed. After the coke has been put on it is advisable to start the blower or fan and so burn the bed of coke to a state of incandescence before charging iron upon it. This allows the sulph r in the coke to ascend the cupola without entering the iron, and less heat is lost than many people seem to think, as the lining of the cupola takes it up, becoming more heated from the bed of coke when no iron is charged upon it, whilst burning to a state of incandescence, than it would be in the presence of the iron.

Charging.

The charging of a cupola is a most important item in its management. The charges of iron should be in proportion to the diameter at the melting zone, viz., 1½ lbs. to the square inch. This is found to be excellent in practice as regards fuel economy, speed of melting, and the temperature of the molten metal. The proportion of coke depends upon the quality of

* Presented before the Birmingham and Newcastle-on-Tyne Branches of the British Foundrymen's Association.

iron to be melted, the following being the suitable proportions per ton of iron melted :—

1.1 cwts. of coke for metal containing up to 50 per cent. of Nos. 1, 2, 3, or 4 common pig-iron.
1.3 cwts. of coke for metal containing from 50 to 80 per cent. of Nos. 1, 2, 3, or 4 common pig-iron.
1.5 cwts. of coke for metal containing up to 50 per cent. of cold-blast or hematite pig-iron.
1.75 cwts. of coke for metal containing from 50 to 80 per cent. of cold-blast or hematite pig-iron.

Continuing with the charging, it is necessary that this should be carried out with a certain amount of intelligence. If not, the man charging a cupola causes the man looking after the bottom or tapping hole a great deal of anxiety. The charging should be carried out evenly and in uniform layers of coke and iron, and not in heaps. The man should be instructed to keep the cupola full to the charging door, and to spread his coke and iron. The writer has known a case where although everything was weighed and the best of material supplied, the working was not successful owing to the cupola not being kept full. When making the charge of coke or iron it was simply tipped on instead of being spread. Consequently the iron went on one side and the coke on the other, with the result that the cupola was melting well on one side, whilst very little was done on the other. The tuyeres were also black on one side, and often had to be blocked up. It is, therefore, necessary for the cupola to be kept full, and each charge put on should be evenly distributed. It is also much more economical, if the scrap will allow, for the charge to be made of pieces not too large. Large scrap causes the stock in the cupola to become open, and much of the ascending heat is allowed to escape before being utilised to heat the descending material.

Cupola Coke.

As regards the coke to be used, the physical as well as chemical properties must be considered; it should be very hard and dense. Pores space is not so essential as the above properties, and the very best coke obtainable is not too good for melting cast iron, proving the cheapest in the end. In mentioning these properties of coke it is advisable to say that coke having too great a pore space is not at all suitable for use in a cupola. It will not stand the pressure of the blast required without becoming very soft, and as soon as the coke becomes hot and just reaches the melting zone the pressure of the blast comes into contact with it, causing the coke to split up as though falling to pieces. Consequently a large percentage is blown away either to the spark arrester or on to the foundry roof. If an inspection is made at the charging door the cupola is apparently working satisfactorily with a coke that has a large pores space. When, however, an examination is made at the tuyeres and of the products, both at the tapping and slag holes, then is the time when a number of cupola men fail to recognise their failure, thus making the management of a cupola such a debatable question. Although the coke supplied may prove to be excellent according to the chemical analysis, foundry foremen and managers should recognise the necessity of purchasing coke by chemical analysis and physical properties combined. Until then the management of cupolas as regards speed of melting, temperature of the metal, coke ratios, and fuel economy will remain one of the everlasting foundry problems.

The tests for indicating the difference in physical properties of different cokes are very simple, being such that any man may carry out in a few minutes, and thus afford a fairly good guide as to the quantity of coke required per ton of iron melted, the amount of metal per hour, and the blast pressure necessary to work the cupola successfully. Take a small average sample of coke from a wagon when being unloaded; put this into water and note what quantity floats well, how much just floats, and what amount sinks, and then judge from the results obtained. The old method of judging coke by its colour is not to be depended upon, neither is it fair to the coke. A very poor quality may have the silver grey colour, whereas a very good coke may be dark or nearly black.

Air Required for Combnstion of Coke.

An ideal coke for cupola work is hard, dense, and does not break to pieces when dropped from a height of 5 ft. on to an iron plate; and most important of all it sinks when put into water. All foundry coke should possess this property. Assuming that its chemical quality is not below the average for British coke, viz., 84 per cent. carbon with 5 per cent. ash, it would give good hot metal with clean melting conditions. Also a coke ratio of 13 lbs. of pig-iron to 1 lb. of coke, or 1.5 cwts. of coke per ton of iron melted, and a ratio of 20 to 1 for charges of iron having a large percentage of scrap. The amount of limestone to use with this quality of coke should be from 25 to 30 per cent. of the weight of the coke charged, a little more being required if the pig-iron and scrap carry an abnormal amount of sand and dirt. Coke of this quality and possessing the same physical properties requires a blast of upwards of 36,000 cub. ft. per ton of iron melted. Although the amount of air chemically consumed by 1.5 cwts. of coke is only 23,856 cub. ft., in practice it is found that upwards of 41,000 cub. ft. of air is required for the combustion of that amount of coke, owing to the fact that the blast must be driven into the cupola at sufficient pressure to reach the centre fuel. More air has, therefore, to be driven into the cupola than is chemically required to consume the coke. As soon as the air enters the cupola it has a tendency to go straight towards the charging door by creeping, unconsumed, up the side of the cupola. The heat produced from 1.5 cwts of coke is 2,276,000 B.Th.U., and to work efficiently these heat units must be produced as quickly as possible. This is very essential, as if they are not produced rapidly very little melting is done. To make this point more clear I need hardly quote anything better than an ordinary fire-grate, and although probably tons of coal and coke have been consumed, the heat has at no time been hot enough to melt pig-iron. This is because the heat units have not been formed rapidly enough. It is therefore necessary that these heat units should be formed as quickly as possible in the cupola, as each layer of coke descends to the melting zone, which can only be done when there is a sufficient volume of air under pressure. With this the chemical change of the coke to the gas is forced just as the chemist urges the chemical changes in the laboratory by heating up various substances. The chemical change in the cupola should take place about 12 or 14 in. above the top tuyeres, and this should be one of the considerations for melting iron in the cupola.

Poorer Cokes.

Another quality of coke which does not possess the hardness, density, or strength of the first sample, does not sink when put into water, but floats with about three-quarters of its bulk submerged, and when dropped from a height of 5 ft. on to an iron plate breaks into pieces, thus showing that it is too

soft. It would not, therefore, withstand the crushing weight of the charges and the rough usage to which it would be subjected when descending to the melting zone, and consequently would not bear the pressure of blast necessary for rapid melting in the same degree as the first-mentioned coke. Although the second sample may be of the same chemical composition, and in theory require the same quantity of air for combustion as the first, in practice, however, the supply of this air would have to be extended over a longer period, and at a pressure 35 per cent. less than that supplied to No. 1 coke. These pressures are 13.5 in. of water for No. 1, and about 9 in. for No. 2.

The cupola also requires more careful attention, because as this coke is fairly soft it reaches the melting zone in a more or less crushed state, the result being that the liquid slag becomes mixed with a portion of the crushed coke, and is chilled by the action of the cold blast. This causes it to gather round the tuyere openings and form a nucleus upon which some of the molten iron drops and solidifies instantaneously. This becomes a growing mass of crushed coke, slag, and drops of solid iron. In addition to this, a fairly large quantity of crushed coke is blown away, as a visit to the spark arrester or foundry roof will show. If the same quantity of No. 2 quality were used as of No. 1 the temperature of the cupola would continue to decrease until melting ceased and the result would be what is termed a "stuck" cupola. To melt successfully with a coke of this quality it is necessary to use 20 to 30 per cent. more than of No. 1. In itself this causes an extension of the melting zone upwards, which is very undesirable in cupola practice. It is also necessary to use 25 to 30 per cent. more limestone to obtain clean working conditions, although by so doing the melting rate is decreased by 20 to 50 per cent. per hour.

A further quality of coke is very soft, floats when put into water, with about 25 per cent. of its bulk submerged, and when dropped from a height of 5 ft. on to an iron plate breaks into pieces and crushes into small bits or coke dust. This shows at once that it is too soft for use in a cupola where anything from 20 to 30 tons per day is required, and would not stand the rough usage or crushing to which it would be subjected. It may have the same chemical analysis as the No. 1 coke, and require, theoretically, the same amount of air for combustion, but it crushes under the burden of the charges and instead of there being good solid coke at the melting zone, there is a kind of coke dust on which the liquid slag and drops of iron settle and form a growing mass. Again, as it will not stand the pressure of blast required to reach the centre of the cupola, the carbon at this point is not burnt to CO_2, but a large quantity is fluxed away with the slag. I may say that it is possible to use this quality of coke when not more than 12 tons of iron are required in a cupola of not less than 30 in. diameter, but this can only be done by reducing the blast pressure to 6 in. of water, and increasing the quantity of coke by 40 per cent. over that of No. 1 quality. The coke dust and the slag become mechanically mixed, and this can only be got out of the cupola by using 50 per cent. more limestone. The latter is necessary to keep the cupola clean, but it is very detrimental to the lining, owing to the fact that the extra limestone attacks the silicon in the firebricks very seriouly. When the cupola is examined, even after a short blow and using this quality of coke, the lining will be found to have worn away 100 per cent. more than it would have done if No. 1 quality had been used. In addition to this the melting rate would be reduced from 6 to 2 tons per hour, and this in itself is very often a serious matter in the management of a foundry. I, therefore, recommend that this quality of coke should not be accepted for use in a cupola. From the foregoing it will be seen that it is not economical to buy cheap material, but more profitable to use the very best that can be obtained.

Before dismissing the coke question, I wish to emphasise the fact that cupola coke must be hard enough to stand crushing and rough usage, without balling, when descending from the charging door to the melting zone. It should be roughly an 4-in. cubes, its density being greater than that of water. It must not fall to pieces when dropped from a height of 5 ft. on to an iron plate, and should possess the approximate composition of 90 to 94 per cent. carbon, 5 to 10 per cent. ash, and not more than 1 per cent. sulphur. With these properties the air from the tuyeres would have a free passage to the centre, which is necessary where economy is considered.

Working the Cupola.

Continuing with the working of a cupola, the coke charged contains from 5 to 10 per cent. ash, the pig-iron and scrap a quantity of sand and dirt. It is necessary, therefore, at intervals to remove this from the cupola, or it would, in a short time, become so clogged as to prevent the operation of melting being carried on. To assist in the removal of this accumulation of matter it must first be made into a fluid, and to do this a fluxing agent is necessary. For general purposes limestone is the best and most economical flux to use in the cupola. The amount to be used will depend entirely on the condition of the pig-iron and scrap, and where this is carrying about 4 per cent. of sand and dirt, and the coke from 5 to 10 per cent. of ash, the amount of limestone required for clean and efficient working will be about 48 lbs. per ton of iron charged. By using this quantity excellent working conditions of the cupola are obtained, the slag runs fluid, and is neither stiff and strong nor spongy. The lining of the furnace is not scoured away by the action of the lime on the silicon in the firebricks, and most important of all, no accumulation is allowed to gather at the tuyere openings. This falls into the molten iron in the hearth and forms a covering or protection for the metal from the action of the blast. The coke burns brightly at the tuyeres, thus showing that the cupola is in an excellent condition at the melting zone.

The removal of the slag from the cupola should be done after every 5 or 7 tons of iron melted with cupolas from 30 in. to 50 in. diameter. The slag hole should be opened, when the slag will either be forced or blown out by the pressure of the blast. It must not, however, be open for more than 15 minutes, as sufficient slag can be removed in that time. If allowed to remain open longer a loss of heat to the cupola results. If left open an abnormal length of time a reduction in the rate of melting takes place, and eventually a decrease in the temperature of the molten metal, causing a serious loss to the foundry. Care should be taken not to remove all the slag from the hearth, as this is a very good covering for the metal.

Limestone.

With regard to fluxing with limestone, it is better to err on the side of too much rather than too little. If insufficient limestone is used the slag is not made fluid enough to run out of the cupola when the slag hole is opened, and the slag being of a tough, strong and sticky nature, a small portion only can be got out of the furnace. This causes the temperature in the cupola to fall, and soon is in a very dirty condition. The slag not dropping freely to the hearth gathers round the tuyere with the result that

it is chilled by the action of the cold blast and masses above the tuyeres, thus taking up a portion of the melting zone and preventing complete combustion of the fuel taking place. The metal melted is very dull, and not suitable for small or thin articles, or castings which require machining. The melting rate falls 20 to 30 per cent., and as very often the cause of this is not recognised, more coke is put on, the cupola, of course, still working no better. The iron will get slightly hotter, but the melting rate falls another 20 per cent., and the slag hole has to be kept open nearly all the time the furnace is running. This causes the loss of a large amount of heat, and as the metal falling in the cupola cannot pass through the tough, strong mass of slag to the hearth, it trickles and splashes through the slag hole whilst open, thus wasting a large percentage of iron.

This bad working is brought about by the lack of the proper amount of limestone. If too much is used it is very detrimental to the lining of the cupola, as the lime combines with the silicon in the fire-bricks and forms a silicate. To express it in practical terms, the limestone scours out the lining, and the sides of the cupola to a very great extent, especially in the region of the melting zone. It has the appearance of a block of ice when pouring boiling water from a watering can over it, and with a melt of from 25 to 30 tons the lining is cut away to a depth of 8 or 10 in. Where receivers are in use there is a danger of the slag scouring the lining away as it runs from the cupola to the receiver, even to the extent of cutting through the casing. Where no receiver is used, the slag, as it runs from the cupola, scours the slag hole out to twice the normal size, and when the cupola is working it boils up into a spongy mass. The blast will carry this up into the melting zone, and cases have been known where the slag has been at the tapping hole, and as high as the tuyeres at the same time, even when the slag hole has been open for some considerable time. Great difficulty is experienced in getting it out of the cupola, owing to its spongy nature, and the slag hole has to be left open all the time the cupola is working, after the first three tons of metal have been melted. As the hole continually increases in size, a great amount of heat is lost, and extra coke is required for the cupola.

Taking all these things into consideration it is far from economical, and shows very bad practice to use more limestone than is actually required. The molten metal should be taken out or drawn from the cupola as evenly as possible, according to the melting rate, the weight of the charge to ensure a complete mixture of the pig-iron and scrap being taken into consideration. The cupola should not be drained or worked from the bottom, and where the charge of iron is from 8 to 12 cwts. there should always be left in the cupola from 6 to 16 cwts. of metal. This allows for the withdrawal of metal in tappings of 10 cwts. for castings of heavy section, and proportionate tappings for castings of lighter section ,and ensures a uniform quality of iron for all classes of work. If the metal is not taken off uniformly, but at say, 20 cwts. at one tap, then 5 cwts., then running to 25 cwts. again, the melting zone is being continually interrupted. It rises and falls as the stock in the hearth rises and falls, with the result that the melting rate cannot be kept constant. Neither can the tuyere openings be kept bright, and very often, owing to bad management in taking metal out of the cupola, more coke is put on.

This is mentioned to show how misleading a cupola is. However, with a little thought after what has been said about coke and limestone, it could be brought under perfect control by adopting fixed melting rates and coke ratios, thus ceasing to be the object of so much controversy amongst engineers.

Discussion at Birmingham Branch.

The Branch-President (Mr. H. L. Reason) in opening the discussion, said that the Paper was most interesting and instructive. Mr. Pemberton had dealt in an especially interesting and effective way with matters which had often been the subject of controversy among foundrymen.

Mr. R. Buchanan said he quite agreed with Mr. Pemberton that in the matter of coke the best was not too good, and that there was no falser economy than to buy a coke supply because it was cheap. With regard to the test of floating in water he did not know that that was quite an original idea, because he had a recollection of having himself some time ago put forward the claim that coke which would float in water should be rejected. There were, however, members present who had found very good coke which would float in water, though this might be only a case of the exception proving the rule. Mr. Pemberton held that in drawing iron from, or gathering metal in a cupola, the height of the melting zone varied. It might be so, but he (Mr. Buchanan) had never observed this, and he had tapped cupolas under all sorts of conditions. He was, however, quite in accord with Mr. Pemberton as to the advisability of not draining a cupola dry, especially when it was a small one. In deciding what should be the height of the tuyeres above the bottom of the hearth, first should be considered what the weight of the castings was going to be, and having settled that point, the best practice was to get the tuyeres as low as possible, but high enough to ensure a properly melted metal all of one kind when it came to be used for the castings designed to be made from that cupola. That was one of the things about which no writer of a paper could give a rule applicable to all kinds of foundry work. It was often quite refreshing to come across really very excellent practice in unexpected quarters. He remembered getting out at a little country station, and going to a foundry there. It was a place where one would expect to find oneself still in the dark ages of foundry practice, but to his surprise and delight, he found that one of the most up-to-date and splendidly managed foundries which it had been his privilege to see. In that foundry, where a great deal of iron was melted, they were melting 12 lbs. of iron with 1 lb. of coke, and he saw that average carried forward from month to month in a properly kept set of books. With regard to what Mr. Pemberton said about an excessive use of limestone, it more often happened that too little was being used. In one place he discovered they were not using limestone at all. They told him they had tried limestone, but had gone back to doing without it. He did not commend that practice for imitation. (Laughter.) It was exceedingly difficult to say anything new about cupola practice. There was a great deal to be learnt about it, but most of it must be by practical experience; there was so much that one could not tell another, and the observant foundryman could learn a great deal more from observation than anyone could tell him. The desirable thing was that each foundryman should pay particular attention to his own methods of melting iron and by doing this and comparing his own methods with those of others he would gain much information which would enable him to produce his castings at the lowest possible cost. The lowest possible cost did not always mean the lowest amounts of coke one could use, because castings could be destroyed by using too little coke just as they could by using too much. The really able man was the one who produced the best quality of iron with the smallest proportion of coke;

but it was well to remember that economies might be carried too far.

Mr. F. E. Robinson asked whether the sand bottom mentioned in the Paper was given in the standard for cupola practice or whether in some cases less sand would be sufficient. That was, of course, with reference to the case of a drop-bottom cupola.

Mr. C. Heggie asked whether Mr. Pemberton could tell them any particular shape of tuyere which he had found most suitable? There was much difference of opinion among foundrymen as to the best shape, and all possible shapes had been used. When Mr. Pemberton gave the increased quantity of coke per ton of iron melted, was he referring to the best coke? Had Mr. Pemberton ever taken an analysis of the escaping gases? With the percentages of the coke given in the Paper it would be interesting to know the percentages of carbon dioxide and carbon monoxide passing away in the gases. With regard to limestone the quantities used had been stated, but not the analysis. There was a great variety of analyses of limestone, and in the amount of silica they varied very much. This had to be considered in deciding upon the quantity of limestone to be used.

Mr. Shaw said he was glad to notice Mr. Pemberton reduced his blast pressure when the coke used was more friable and softer, because it seemed to him (the speaker) that the pressure used should be governed by this fact, to some extent. At the same time, by lowering the pressure the volume of air delivered in a given time was reduced, unless the tuyere area was increased. This fact would, to some extent, account for the slower melting. While not an advocate of high pressure he had used a pressure of 1¾ lbs. with no bad effects on the iron, except a higher loss of Si. and Mn.; but, of course, it was hard on the cupola lining. If the statements made by Mr. Buchanan and others, that no oxide was present in molten grey iron where a fair amount of Si. and Mn. was present, were correct, a fairly high pressure could not matter so far as the iron was concerned. Mr. Pemberton had given some useful information as to the best coke to be used. At the present time many foundrymen were glad to get coke at all. He (the speaker) was using about 60 tons per week, and if the author could tell him where to obtain fuel with the limits prescribed, at a reasonable price, he should be his debtor. The coke consumption given by Mr. Pemberton he considered exceptional. In some of their shops they get down to 1.5 cwts. per ton melted (including bed), when running continuously (say 40 tons per day), but in other departments it was higher. The height at which the tuyeres should be placed, he continued, depended entirely upon how much metal it was desired to store in the bottom of the cupola. The lower the tuyeres could be placed the more coke was saved in the bed. He could not agree with Mr. Pemberton's reasons for leaving so much metal in the hearth when stopping up. Where several mixtures followed each other for different work it would not act at all. While thanking Mr. Pemberton for his excellent Paper, he did not think the rules given would do for every shop. Each must consider the nature of his own particular work. The practice must depend upon what had to be done and the materials and conditions at hand. The thing to do was to hear how these excellent results were obtained, and to add to our own practice all that was helpful and tended to economy.

Mr. F. J. Cook said that, whilst he had been very greatly interested by Mr. Pemberton's Paper, he must agree with the last speaker that the Paper was conceived on too narrow lines. Each different class of work would require different cupola practice. The Paper was so definite that one would think every condition was alike. Mr. Pemberton, in speaking about the tuyeres, made a definite statement that one-ninth was the correct proportion to use. That was Kirk's recommendation, and for small soft castings he (Mr. Cook) believed it was correct. It was necessary to get into the cupola a certain volume of air, and the pressure required to get that in had to be in proportion to the area of the tuyeres. With some classes of metal it was advantageous to use a less tuyere area and correspondingly higher pressure. On the debatable point as to whether a receiver should be used or not, he was at one with Mr. Pemberton when the receiver was placed outside, but where the receiver was inside, as in the double-bottom cupola, he much preferred it. He had had one of this type in use for a number of years, it had none of the disadvantages of the outside receiver and all the advantages of a mixer, and made for economy, inasmuch as there was the same saving in the height of the coke bed as claimed for the outside receiver. Mr. Pemberton had spoken of the coke being in proportion to the metal melted, but the proportion must also depend upon the quality of the coke used. He was quite in agreement with Mr. Pemberton as to the necessity of taking account not only of the chemical analysis of the coke, but also of its physical properties. But he did not agree that a coke which would sink in water was the only coke to use. One of the worst cokes he had ever used—it was bought during the strike (laughter)—had distinctly the quality of sinking, but certainly not the other qualities desired. He was also quite convinced that it was possible to get a coke that would float, and still have all the good qualities desired. They had to consider not only the chemical and the physical properties, but also the action in the cupola of the coke that was to give the most economical results. A foundryman who did not take an analysis but only tested his coke in water as suggested by the lecturer might very likely be led to make a mistake. As foundrymen they had to use coke by measure, because they had to keep a certain height of coke bed in the cupola, therefore the lightest coke, provided that its other qualities fitted it to give the best results, was the most economical to adopt. If they could get a coke that would float and the chemical analysis was all right, then it was a more economical coke to use than one that would sink. He knew an excellent coke which would sink and had all the qualities postulated by Mr. Pemberton; but three cwts. more of this coke were required for the bed of a certain cupola, than of a coke which was equally good in melting power, and which did not sink. With regard to the estimate of 33,600 cubic feet of air to melt one ton of iron, he (Mr. Cook) had made a number of experiments on pressure, and would like to know Mr. Pemberton's method of measuring the volume of air—whether the height of the barometer was taken into consideration and also whether allowance was made for temperature in estimating the volume. If the volume was obtained by counting the strokes of the piston or the revolutions of the blower it was not a satisfactory method, and the estimate would also be very materially affected by the temperature of the atmosphere and also by the height of the barometer at the time the estimate was made.

Mr. J. Grant, though he quite agreed with Mr. Pemberton on most points, questioned the statement as to the effect drawing had upon the position of the melting zone. He did not think it could have the least possible effect. He thought that when the molten iron passed below the blast level it could not effect the height of the zone. He was aware that the melting zone was sometimes higher than it should be, but this condition was due to other causes than that stated by Mr. Pemberton. The molten slag and iron below the tuyeres occupied the porous spaces only, and could not possibly effect the rise or fall of the

coke bed, or change to any degree whatever the height of the melting zone. As to the question of the blast-pressure, he thought that provided the necessary volume was got, the lower the pressure of the blast the better in all cases, and with all kinds of iron. With a low pressure so much trouble was not experienced from those long stalactities of dirt out of the slag forming on the tuyeres as with high pressure. He quite agreed with all that Mr. Pemberton said about coke. Everything depended upon that and upon proper methods of charging. It was a most necessary thing to have the charges thoroughly level. He did not think anything could be worse than to have the iron all on one side and the coke all on the other.

Mr. Pemberton, replying, said that with regard to excessive use of limestone, he knew this did not often happen; more often too little rather than too much was used. He gave the warning, not necessarily because some of the members of that Branch required it, but because he thought it would be an advantage to the foundry industry generally to have it pointed out that excessive use of limestone was detrimental in cupola practice. With reference to tests of coke he did not claim that the water and other tests he had suggested were original, but he did claim that they were practical. (Applause.) Some of the speakers had differed from him as to the rise and fall of the melting zone, but if they reduced the height of the molten metal in the hearth of the cupola the superincumbent layers of coke and metal were bound to come down and (as Mr. Pemberton showed by a diagram) the position of the zone of maximum temperature was, for the time being, altered. If they only drew off a comparatively small portion of the metal, they were continually interfering only with a small proportion of the melting zone. Therefore, he said that metal should be taken from the cupola in uniform drawings, not 25 cwt. at one time, then 5 cwt., and then again 20 cwt. By making the tappings uniform and timing them uniformly with the charges, the temperature of the melting zone was kept more constant, with a gain in quality of metal and saving of fuel.

With regard to the sand bottom, he continued, the lowest thickness he had mentioned was 9 in. He had not the least doubt that one could work even with a four-inch sand bottom, provided it was formed with a good sand, but it was better to err on the side of safety than on the other side. (Hear, hear.) With only a small depth of sand one never knew how near one might be to a catastrophe. With regard to the shape of the tuyeres, personally, he preferred a tube slightly tapered away from the nozzle, so that any iron that might rise in it could easily be removed. He did not think there was anything in the question of whether the tuyeres should be square, oblong, oval, or round, as long as they were the right size and in the right position. As to carbon monoxide in the escaping gases, they had taken analyses and found practically only a very slight trace. The figures he had given for coke included the bed. In reply to Mr. Heggie he had the analysis of the limestone used, which was:—SiO_2, 2.5 per cent.; Al_2O_3, 1.25 per cent.; Fe_2O_3, 1.5 per cent.; CaO, 50.0 per cent.; MgO, 2.0 per cent.; CO_2, 42.75 per cent. This was found to be very good. In reply to Mr. Shaw he might say that Durham coke was very good. Mr. Shaw told them that his cupola worked very well with a high blast pressure, at any rate one above that which he (Mr. Pemberton) had given for his cokes. He had an idea that if Mr. Shaw used a higher pressure than 13 in. of water and analysed his slags he would find the percentage of iron in them very high; no doubt it would run into double figures. As to leaving metal in the bottom of the cupola, it was advisable to drain the cupola only if changing the quality of the metal, as from a first class hematite iron to very common iron, and then to machine iron. Then it was advisable to drain the cupola, but it could be done with an extra charge of coke, though this was an unnecessary waste of coke. It was neither economy nor good practice to work the cupola from the bottom. It was better to work it from a point a little above, but of course the cupola attendant would always have a leaning to work close to the bottom, because, in that case there was not so much risk of having a spill. Mr. Shaw spoke about the rules and regulations given in the Paper not applying to every shop, and claimed that every shop must work out its own practice. If they still adhered to that adage it was of no use for anyone to read a Paper on the cupola, because the cupola would remain the one everlasting problem among foundry engineers. If it was impossible to bring the cupola problem down to a fine point in the foundry world they should endeavour to do so. That had been his object in writing that Paper. He had given them what he knew of cupola practice, and if anyone else would do the same on any other subject he would be pleased to accept it. (Applause.) Mr. Shaw had spoken about melting 100 tons per day in the cupola with no trouble, with 1.5 cwt. of coke per ton of iron melted. He was with Mr. Shaw every inch of the way, and would say that gentlemen who were melting 100 tons per day with 1.5 cwt. of coke were somewhat behind the times, because they ought to do it with less than that. Mr. Cook regarded the Paper as being upon too narrow lines, but his (the speaker's) object was to give that practice that appeared to him the best, and to bring the question of cupola practice to a point, so that they might be free to consider further developments. He had done his best in that respect, but he was well aware that in coming to Birmingham to give his ideas of a definite system of cupola practice he must expect to get into a row. (Laughter).

With regard to the tuyere area of one-ninth, continued Mr. Pemberton, he had given his own practice, his experience having proved that one-ninth was the correct area with all the classes of coke he had recommended, having regard to their chemical analysis and physical properties. He did not think that the increasing of the blast pressure for hard irons, spoken of by Mr. Cook, was the correct thing to do, because if they wanted to harden their iron they could do it more economically by using cheaper material than by blowing the elements out of soft iron. He did not consider it good practice to make iron hard with the blowing engine. Mr. Cook had spoken of the Máchiel cupola with a receiver. This was an exceptional cupola, and he did not know anyone besides Mr. Cook who was using it. It might be all right as far as the receiver was concerned, but he was afraid that in that cupola Mr. Cook did not get the height required for utilising the escaping gases and the heat from the charge by having the receiver inside the cupola. With regard to receiver outside the shop, he was opposed to it altogether on account of the cost of upkeep. As to buying water in coke, analyses would show whether or not the sinking was due to contained moisture. He had the analysis of coke in which the moisture was only 0.42 per cent. The physical tests must be taken into consideration along with the chemical tests, or their estimate of the quality of the coke would be altogether wrong. A coke might be excellent to its chemical analysis, also excellent with regard to density, but density and volume in coke were two totallly different things, because if they got a dense coke with a large volume, this meant a large pore-space and thin walls between

the air-cells. Now, though this coke might be in a sense a strong coke, the walls between the air-cells would be found not strong enough to stand the crushing weight of the charges of iron as they descended from the charging door to the melting-zone, and the result would be that when the coke reached the melting zone it would not be a solid material able to resist the pressure of the blast, but would be in such a crushed state that a portion would be blown away. Therefore, it was not essential, neither was it economy to buy or use coke by volume or by measure. If it were bought by weight, then let it be used by weight. As to the volume of air, his practice was to estimate it by the revolutions of the blowers, and then, taking the temperature of the atmosphere, correct the calculation to the volume at normal atmospheric temperature, which he took as 65 deg., the thermometer being kept near the blowing engine. Mr. Buchanan spoke of lowering the blast pressure, but if they lowered it too much they could not get the oxygen to the centre of the cupola. With a 30-in. cupola, to get the air into the centre it was necessary to have a pressure of 13 in. of water. On the other hand if they had the pressure too high, especially with a low quality of coke, then a large quantity was blown away, but it was not economy to use a low pressure for the sake of being able to use a poor coke.

On the motion of Mr. Morgan, seconded by Mr. Cook, a hearty vote of thanks was given to Mr. Pemberton for his Paper.

Discussion at Newcastle-on-Tyne Branch.

Mr. Fargrave asked whether Mr. Pemberton found that, in using an excess of limestone in the cupola, it always attacked the silicon in the lining in preference to the silicon in the iron. He also would like to know what Mr. Pemberton found, in testing the coke by means of water as shown by him, if the coke happened to be very wet at the time.

Mr. Paulin said that Mr. Pemberton seemed to work with a very low blast pressure, and he could not understand how he got that low blast into the centre. He supposed Mr. Pemberton would be dealing with a melting zone of about 30 inches; for that size cupola he (Mr. Paulin) had generally seen a pressure varying from 12 ozs. to nearly 16 ozs. used, which was more like twice the pressure given in the paper.

Mr. Weir said that, in regard to the two rows of tuyeres mentioned, some foundry owners adopted the German principle of a spiral tuyere, which was very good in some instances but was detrimental to the quality of the iron produced. It was a debatable question; every foundryman had his own method and his own ways with regard to tuyeres. He would like to know whether Mr. Pemberton preferred the method of the double tuyeres in his cupola, and what would be the result if he had to get down perhaps 70 tons or 100 tons of metal; at the end of the day, what would his furnace be like?

Mr. Henderson asked whether Mr. Pemberton had had any experience of retort coke, and if he could recommend it in preference to beehive coke? He would like to know whether Mr. Pemberton considered it would be beneficial to have the coke carrying about 10 per cent. of moisture in it, and also his opinion as to the comparative values of fluorspar and limestone as a flux, from the point of economy; also whether the fluorspar was better for the iron in carrying away some of the oxides and other impurities. Then, with regard to the eating out of the furnace, what was the action of the blast with regard to that. Mr. Pemberton had spoken about the blast having a tendency on entering the cupola just to creep away up the sides. They had had a discussion recently, and it seemed, from that discussion, that the members had pretty well concluded that the blast, instead of creeping away up the sides, actually went right to the other side. The question had sometimes been raised of having the tuyere narrowed as it entered the furnace for the purpose of increasing the pressure and carrying the blast right into the centre of the cupola. He supposed Mr. West's introduction of the blast into the centre instead of the side was with the idea of getting the air right into the middle of the furnace, but he, Mr. Henderson, would suggest that air being very elastic, as soon as it entered the furnace would quickly equalise itself in the way of pressure wherever there was a space in between the coke, and not only that, but it would go right to the other side and eat out the lining opposite the side at which it entered.

Mr. Gallon asked what Mr. Pemberton meant by taking 20 to 30 per cent. more of one coke than another, whether this was by weight or by bulk. He had always held the impression that if you weighed your coke you could not get far wrong in the melting. With regard to the limestone eating away the lining, he had seen a cupola more burnt out where there had been no limestone used than he had at any other time. He was of the opinion that the blast was a very great factor in burning out the lining of a cupola. He had seen cupolas worked with gas-coke, but this was very poor practice, and they had very hard work to get any good metal. He was quite of Mr. Pemberton's opinion that if coke cost one-third more for the best than it did for the worst, the more expensive coke was cheaper in the end. With regard to the tuyere area, he was of the opinion that the area of the tuyeres ought not to be less than one-quarter of the area of the cupola at the melting zone. He would even go a little further than that. He had a small cupola, 27 ins. at the melting zone, and he did not know whether it was the cupola-man's fault or not at the time, but they could not get any more than 25 cwt. an hour out of that cupola. They were then running with two tuyeres, one on each side of the cupola, direct in. He tried increasing the tuyere area to 25 per cent., the result being that, instead of 25 cwts. per hour, they got 2 tons 5 cwts., with about 33 per cent. less coke burnt.

Mr. Matthews referred to the cupola charged with the coke right up the centre. He had heard of a foundry in that district adopting the practice, and the man in charge said it was very satisfactory. He would like to know whether Mr. Pemberton would recommend blowers rather than fans.

The Chairman said that Mr. Pemberton's remarks on coke had appealed to him in view of the amount that was wasted by grit and the burning of carbon monoxide at the upper portion of the cupola. He would like to ask Mr. Pemberton what was his opinion as to the height from the tuyere to the charging door, and what influence that had on efficient working; whether the extra height from the tuyere to the charging hole would tend to economy by heating up the mass, or whether it would tend to the production of CO, and consequently a loss in heat. It was a very common practice to contract the cupola above the charging door, and so increase the resistance of the large volume of gases which were passing up the cupola. His own opinion (the Chairman's) was that the cupola should not be contracted, but should be carried to a decent height above the charging door. Mr. Pemberton's low pressures might have something to do with the reduced cutting action on the lining of his cupola. With high pressures and cupolas of comparatively small diameter—he took it the larger the diameter of the cupola the higher the blast pressure necessary to reach the centre and to rise through the burden of the cupola—but with small cupolas and high air pressure, there would be considerable danger of heavy cutting action above the tuyeres on the opposite

side of the furnace. In regard to the question of wet and dry coke which had been raised, some foundries advocated keeping coke absolutely dry, but this depended very much upon the cupola. If the height from the tuyeres to the charging door was low, then dry coke should be used. If, on the other hand, the height was excessive, it was quite possible that wet coke would be an advantage because it tended to lower the point at which the coke became incandescent and concentrated the melting zone into its proper place. With an excessively high cupola and dry coke, the chances were the melting zone became too high. The coke consumptions mentioned by Mr. Pemberton showed that the practice which was adopted in the management of his cupola could not be very far wrong, and the low and efficient working that had been shown warranted their giving very considerable attention to his remarks.

Mr. Pemberton, in his reply, said that there was more silicon in the firebrick than there was in the iron, and, therefore, the limestone would attack that which it was easiest to get at; it would attack the silicon in the firebrick before it would attack the silicon in the iron. As regards applying the water test to wet coke, if one had a wagon-load of coke which had come through a thunderstorm, then it would be advisable not to put that directly into the water, but to dry it before making the test. The water test was simply a practical test, and should be used in conjunction with the chemical test. Sometimes a coke would give an excellent chemical analysis, but, on being put to the water test, would be found to be of very little use in the cupola. On the question of the low pressure, he had been dealing in his paper with cupolas of 30 ins. internal diameter, and he wished to make it quite clear that those blast pressures were proportionate for all cupolas up to 50 ins. in diameter. He did not recommend the centre blast except for one thing, that was when they were just on the verge of the capacity of a 50-in. cupola; rather than put down an extra cupola, two smaller ones, say of 30 in., it was advisable then to attempt the centre blast. A queston had been asked about two rows of tuyeres versus the spiral tuyere. Unfortunately, he had not come across the spiral tuyere in this country, but he had seen some of the French tuyeres, and he had seen one which was supposed to be one of the best French cupolas existing at that time. It was supposed to take off the gases from the top of the cupola and heat them up in the bottom; that was taking off the CO on the top and converting it to CO_2 at the bottom. He did not think very much of it, because it was not necessary to have CO on the top of the cupola; that should all be consumed at the bottom. He would advocate the double row of tuyeres, for the simple reason that the first air that struck the carbon formed CO. The air coming in at the second row of tuyeres converted the CO into CO_2, thus giving a complete combustion of the fuel, and there was no flame at the charging door. If the CO was not converted into CO_2 down in the melting zone, then it would pass up the cupola to the top of the charging door, when the air would come in contact with it and a blue flame would be seen. He would have about 16 ins. between the two rows of tuyeres. As to retort coke, he did not see that beehive coke could be beaten for good and efficient working, but excellent retort coke could now be obtained and makers deserved credit for trying to make retort coke suitable for foundry purposes. In many cases retort coke would be found to give excellent results. With regard to wet and dry coke, he did not think it was advisable to put moisture into the cupola at all, as a certain amount of heat was required to absorb it. He would not advocate charging coke in the centre of the cupola and having the iron all round, for the reason that the iron would come down somewhat red hot, or partially melted, and there would be a tendency to blow a lot of iron from the cupola. The question of blowers versus fans was a paper in itself; he used both. The height of the cupola to the charging door was 16 ft. 6 in., which was probably exceptionally high. In regard to waste heat, it was possible to walk on top of the cupola he had been using, so there was no heat getting from the top, all being utilised on the material. As regards the air pressure and the cutting action, by using the low-pressure blast the cupola was not cut out so much as it would be by using a high-pressure blast, but it was necessary to put the air into the cupola at a sufficient pressure to enable it to reach the material.

Mr. Smith asked what a cupola of 42 ins. in diameter, with two rows of tuyeres, should melt.

Mr. Pemberton said about 7 tons. In answer to a further question he said that better results were obtained from the two rows of tuyeres than from one row, as far as melting was concerned.

Mr. Smith said he had a furnace exactly 42 ins. in diameter, with one row of tuyeres, and it melted about 7½ tons an hour. He had been very much interested in the paper, but, as far as cupolas were concerned, he sometimes thought that foundrymen were getting too high notions. They had patent cupolas coming on to the market for which £250 and £300 were asked. He had built a furnace for less than £50 that served his purpose well, and was giving good results.

Mr. Weir, in moving a vote of thanks to Mr. Pemberton for his Paper, said he agreed to a large extent with what Mr. Smith had said; but they had seven furnaces of the old-fashioned type in use, and the results obtained were far above those given by Mr. Pemberton.

The vote of thanks was unanimously passed.

Correspondence.

Core Sand for Motor Cylinders.

To the Editor of the Foundry Trade Journal.

Sir,—Regarding to the oil-sand mixture given on page 308 of your last issue, to do away with venting, I should be very much surprised if it proved successful under the conditions of practice. The cohesiveness of Birkdale sand is so small that any attempt at making the very intricate cores required in motor-car cylinders would be disastrous. It is a good mixture where there is a clear draft, but under the system of making core boxes at present adopted, the core-maker would be unable to produce a sound core. For instance, the shell core requiring supports on account of the metal completely surrounding the core, would very easily be fractured on account of the draft of box. For this class of sand mixture to be successful, the core boxes would have to be made in sections, so that each part would draw clear away from the core; this would give the core-maker a better chance of having his core sound. The cores are hard enough when dry, but the least jar or touch in the wet state will spoil a core very easily. As motor-car cylinders can be classed as small castings, a cheaper binder can be used with this Birkdale sand with better effect, because the risk of not having the oil thoroughly dried out is done away with, and the sand absorbs instead of giving off gases. But in all cases the core boxes would have to be made after the manner quoted.

Yours, etc.,

J. Peers.

"F.T.J." Bookshelf.

Traite Pratique de Fonderie.

By A. Lelong and E. Mairy. Paris: Ch. Béranger, 15, Rue des Saints-Pères.

French foundry literature has just been augmented by a very comprehensive treatise, in two volumes, covering grey-iron castings, malleable iron castings, steel castings, and copper and the non-ferrous alloys. The authors are men of considerable technical qualifications, and are both members of the Société des Ingénieurs Civils de France; accordingly the practical and scientific sides alike of the subjects are well treated. As an introduction to the actual foundry chapters, the production of pig-iron is briefly considered. The authors then take up the general subject of the principal materials necessary for the founding of iron. Under this heading are considered iron and its properties and varieties, the constituents of the metal and their influence, and coke and its properties. The laboratory comes next under survey, and its equipment and processes are discussed to some length, including the subject of photomicrography. Coming to the melting and pouring of iron, the crucible furnace is first considered, and the construction of furnaces according to a number of different European systems is described and illustrated. Reverberatory furnaces of English, American and German types are next considered, and the reactions during melting discussed, after which the cupola comes in for treatment. This subject naturally, is dealt with to greater length than is the case with the other melting systems. The general principles are first outlined and then the quantities of air required for proper melting are considered and calculated; the form and position of tuyeres, the shape of the cupola's interior and the general construction of the furnace are also discussed. Brief attention is also given to cupola receivers and dust-catching apparatus; and the authors then pass on to the questions of blowers, the blast-pipe systems for cupola work, charging apparatus, pig-and scrap-breaking and weighing apparatus, ladles, and other accessories to cupola working. We may say here that the treatment of cupola construction appears somewhat meagre, though much valuable information is given in the succeeding chapter, which deals with cupola working. Under the title of "Specifications, Mixing and Analysis of Irons," a number of mixtures (with analyses) are given to meet particular requirements; and in this connection it is interesting to note that Scotch and English irons are frequently included in the mixtures. In this chapter the testing of iron and the different apparatus therefor are included. Materials employed for making the moulds and cores are next dealt with, and various sands and mixtures are discussed as regards both their chemical and physical characteristics; while the apparatus for the preparation and handling of sands for moulds and cores form the subject of a separate chapter, in which typical installations of sand preparing plant are depicted. Coming next to the general accessories of foundry work, the authors discuss in turn cranes, hoists, and cables, hydraulic power and compressed-air installations; and following is a chapter dealing with the tools, flasks, and numerous smaller appliances in the foundry. A good deal of useful information is here embodied regarding the sizes and arrangement of moulding flasks. The latter half of the volume is devoted to moulding proper, and the appliances and apparatus used, a good portion dealing with various moulding machines. Coming now to the second volume we find the subject of moulding further elaborated on, the operations for a number of specific pieces of work being described and illustrated. Core-making in its different aspects is well discussed, and a variety of mechanical core-making machines are described, in addition to different forms of core- and mould-drying ovens and apparatus. Discussing the pouring of moulds, the authors enter into the calculation of pressure in the mould and give a number of examples; they also deal with the calculation of the weights of castings of different shapes. The cleaning, dressing, and examination of castings, and the apparatus for this work occupy over 40 pages, and brief attention is given to the separation of iron from foundry refuse. After discussing to some length the different defects which occur in iron castings, and various methods of repairing them, a general treatise on the installation and organisation of foundries closes the portion of this work dealing with grey cast iron. Part II. takes as its subject malleable cast iron, and in the course of about 30 pages the authors give a full and careful survey of the process and its requirements, discussing the properties of the metal, its composition and manufacture, the furnace (this somewhat briefly), and the annealing ovens and pots. This subject might, perhaps, have been treated much more fully, for although the foregoing section on grey cast-iron covers a good deal that would have to be included in a separate volume on malleable cast iron, the subject is one necessitating considerable attention to details which are peculiar to malleable work. Part III. of the book deals with steel, and in the opening chapter the authors give a full and careful survey of the properties and varieties of steel castings. The crucible process, so far as the apparatus goes, receives but scant consideration, though the Siemens regenerative gas-fired crucible furnace is described and illustrated. The Bessemer process and its modifications figure more prominently, the authors giving a careful survey of the process and practice of producing this class of steel. As regards open-hearth steel production, this subject, while dealt with carefully, is rather too briefly treated in view of its importance and special features; the construction of the furnace, the regenerators, gas producers, etc., is described, but only in brief. The authors then pass on to the electric furnace, discussing its advantages, the nature of its products, classes of furnaces, etc. The Gin furnace is given as a typical resistance furnace, and the principles upon which the Kjellin and Roechling-Rodenhauser induction furnaces are constructed are briefly discussed. The arc furnaces described include the Héroult, Stassano, and Girod, the construction and operation being outlined. This section, however, is only an outline survey of the subject of electric-furnace steel. A brief chapter on the actual founding of steel, including methods of moulding, sands, pouring, etc., closes this part of the book. The authors then discuss, in Part IV., copper and the non-ferrous alloys. Here in the space of about 70 pages they have managed to condense a mass of information on alloys, their production and methods of casting, as well as describing several modern furnaces and giving an outline of a typical foundry lay-out. Taken as a whole, these two volumes form an extremely valuable survey of foundry practice. The specialist in any one branch

would do well to supplement them by works dealing with such special subjects, but for every branch there is much in the books before us that will be well appreciated.

The Principles of Ironfounding.

By A. Humboldt Sexton, F.I.C., F.C.S., and John S. G. Primrose, A.G.T.C., A.I.M.M. London: The Technical Publishing Company, Limited, 55 and 56, Chancery Lane, W.C.

The scientific side of foundry work has been brought well to the front of late years, and at last it is becoming realised by all connected with the trade that the principles upon which the melting and casting of metals is based must be the founder's constant study. The general practical treatise on foundry operations serves a very useful purpose, but covers only half the subject; and some modern foundry text-books, accordingly, embrace both. In the book before us the principles upon which good practice is based are the chief considerations, although brief instructions on general practical procedure also find space. The properties of pig-iron, the classification of the metal, the phenomena of solidification, and the fuel used in cupola work, are in turn discussed, and in this section foundry metallography figures conspicuously. The authors then deal, somewhat from the theoretical standpoint, with the different subjects connected with cupola operations. Air furnaces are next briefly considered, followed by a fairly full general outline of the principles of pattern-making, moulding, core-making, core-drying, etc. Chill castings and malleable cast-iron also come in for brief treatment. A good deal of useful information is embodied in chapters on, respectively, defects in cast-iron and the testing of cast-iron, while an appendix tabulates a number of useful notes and data. There is much in the book that may strike the advanced foundryman as somewhat elementary; but this is perhaps essential, since many sides of the subject can necessarily be treated only in outline in a work discussing principles rather than details of practice. There is much of considerable value contained, though the general style, tinged as it is with the colour of the technical class-room, suggests rather an engineering student's handbook than a practical foundryman's scientific text-book.

Queries and Replies.

Renovating Foundry Sand.

There is a substance which has recently been placed on the market by a firm of foundry specialities of Manchester, used for renovating spent foundry sand. It is said to be very successful in all kinds of moulding, the waste sand being rendered capable of use over and over again, and it is also claimed to save about 50 per cent. of the cost of new sand used, plus other advantages. I should be pleased to hear if any of your readers have had experience with this renovator and with what success.—"ENQUIRER."

Core Mixture for Valves.

In the manufacture of brass castings (plumbers' goods and steam valves) the writer experiences trouble in making the thousands of small cores required for cocks of various shapes. He has made many experiments in endeavouring to find a suitable liquid for these small cores, but without success. Have any of your readers had experience in this matter, and can they advise what to use?"

"R. W.," Germany.

Difficulties with Malleable Iron Castings.

Reply.—Regarding the query of "Constant Reader" in your April issue, respecting malleable cast-iron wheels with arms, a similar case came under the writer's notice very recently, but instead of a double process of annealing, as stated, the castings had to be made three times to get sound castings. The order was for six, and the castings were made in one day. After leaving the sorting shop, apparently sound, they were annealed, but after annealing every wheel was found to have fractured close to the hub or boss. Another attempt was made; this time each arm had a small bracket cast on, this bracket being used as a trying piece from the arm to the boss, and as it was impossible to say which arm would fracture, there had to be one on each arm. After the annealing of the second series, the fracture occurred in the middle of the arm; the brackets had prevented the fracture close to the boss, but by adding bulk to the boss had caused the fracture to occur as stated. The third series had no brackets cast on, but after the pattern had been drawn, by the aid of the tool, sand was taken out of each arm, and smoothed down, thus strengthening the arms and all parts being more equal. These turned out sound. The idea of saving weight, as in the case quoted, often leads to bad results, if the fracture does not reveal itself when the casting leaves the sand, it is very often the case that it does after annealing, through the unequal contraction and expansion. When the time is totalled up as in this case, say, one day moulding, one day to pass through sorting shop, and six days annealing, three times over, the delay in delivery is easily accounted for. As regards a double process of annealing, the writer has never heard of it, this merely being an excuse to gain time.—J. PEERS.

Power for Fettling Shop Driving.

Reply.—As apparently both this and the succeeding question (appearing in your issue of last month) in regard to lighting emanate from the same source, it appears to me that electricity would be more economical than either shaft or cable drives, while, if properly arranged, the total loss of energy between points of origin and use would probably be much less. By using separate motors for each machine, or group of machines, in constant work, it is possible to keep the current consumed to the lowest point, while with dustproof motors there would be practically no trouble from dust. In regard to long shaft transmission drives, stout shafting, with a sufficient number of bearings, would be necessary, and, unless carefully aligned, would involve much loss of energy from point to point. Beyond this, the oiling and keeping clean of the bearings is somewhat of a nuisance in a foundry, because it is not easy to avoid a large amount of sand rising while pouring is taking place, which dust, being fine, works into every place where a lodgment can be found. Cable drives would too often be found difficult because of the trouble in splicing, while probably there would be a large amount of slip unless very carefully and well-designed pulleys were used. Even then, however, there would be the drag of the bearer pulleys, which would have to carry both forward and backward halves of the rope, and steel wire rope capable of transmitting 20-25 h.p. at a moderate speed is not exactly light when run on the flat. Electricity would no doubt give the best all-round results, and this I should personally select where possible.—WALTER J. MAY.

Inventions.

Applications for Patents.

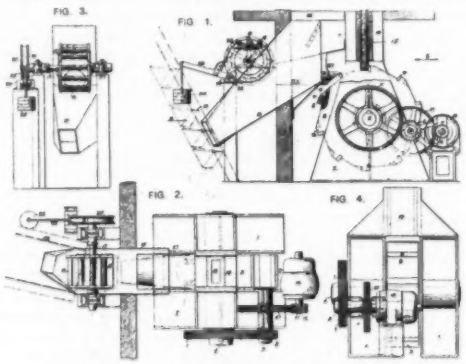
An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

8,882.*Furnace doors. (Knox Pressed and Welded Steel Company, United States).
8,883.*Regenerative furnaces. (Knox Pressed and Welded Steel Company, United States).
8,884.*Water-cooled furnace-door frames. (Knox Pressed and Welded Steel Company, United States).
8,946. Puddling furnaces. F. J. Millard and R. J. Hadlington.
9,986.*Metallurgical furnaces. G. H. Benjamin.
10,154.*Hot-blast stoves. M. Schroeder and H. Reinhard.
10,172. Casting-machines. F. H. Alston.
10,216.*Foundry flasks. I. R. Smith.
10,494. Furnaces for melting metals. F. J. Clinch-Jones.
10,882.*Production of ductile iron. H. Plauson and G. Tistschenko.
10,963.*Vacuum casting-devices. (Ransom & Randolph Company, United States.)
11,080. Incorporating materials or metals with steel and alloys of steel. E. H. H. Gordon and R. J. W. Brown.
11,081. Manufacture of steel and alloys. E. H. H. Gordon and R. J. W. Brown.
11,118. Moulds for the casting of copper, brass, iron, steel, etc. J. A. Davies.
11,124.*Grinding machines. Churchill Machine Tool Company, Limited, S. H. March, and H. H. Asbridge.
11,186. Tube-casting moulds. J. Hayes.
11,340.*Casting pipes in rotating moulds and apparatus therefor. J. Orten-Böving and H. J. Molinder.
11,488. Electric furnaces. C. Dellwik.
11,526. Finishing sand and other moulds for casting purposes. William Mills, Limited, and W. Mills.
11,735. Production of black heart malleable iron castings direct from the cupola. S. Coleman.

Abstracts of British Patent Specifications recently accepted.

25,915 (1911). *Refining of Iron and Steel.* K. A. F. Hiorth, 13, Josefine Gate, Kristiania, Norway.—The melt produced in the usual way is first dephosphorized for instance by adding ore or by blowing. The phosphorus is thereby driven into the slag so that the contents of phosphorus in the iron will be reduced for instance from 0.06 or more down to 0.008 per cent. The iron thus obtained, and which is practically free of phosphorus is now poured into a ladle or similar receptacle, either completely, or, so that a small quantity of iron remains in the furnace together with the phosphorus containing slag. If all the iron is poured off a small quantity of cheap iron is poured from a cupola furnace or the like into the furnace. The charge in the furnace which now, therefore, consists of some iron together with phosphorus-containing slag is then treated with carbon, so that the phosphorus is reduced off and taken up in the molten metal below. The small quantity of iron rich in phosphorus that may have been obtained in this manner, is a valuable product which may for instance be used in the basic Bessemer process. This iron is poured off whereupon the iron obtained by the above mentioned dephosphorization process, and which is free of phosphorus, is poured back from the ladle (or other receptacle) into the furnace. Additions or special treatments that may be desired, may be carried out whilst the iron is in the ladle. The treatment of the iron poured into the furnace, and which is free of phosphorus may then be completed and the iron freed from gases under the action of the slag that is free of phosphorus, and which may afterwards be used again with a fresh charge, and so on.

26,418 (1911). *Apparatus for Breaking Pig-Iron.* The Enterprise Manufacturing Company, Pennsylvania, U.S.A. Fig. 1 is a side view of the apparatus partly in section; Fig. 2 is a plan partly in section with the floor removed; Fig. 3 is an end view looking in the direction of the arrow *a*, Fig. 1; and Fig. 4 is an end view looking in the direction of the arrow *b*, Fig. 1. 1 is the frame of the improved pig breaker and mounted in bearings in this frame is a shaft 2, on which is mounted the breaker wheel 3. This breaker wheel has a series of teeth 4. The front of each tooth is on a radial line with the centre of the shaft, while the back of the tooth gradually tapers off to the base of the next tooth. It is preferable to mount a steel plate 5 on the face of each tooth and to secure the plates to the teeth by bolts 6, as clearly shown in Fig. 1. The wheel 3 is rotated at such a speed that it strikes a blow, and by making the striking faces of the teeth of hard metal, the teeth have sufficient body to resist any such blow. On the shaft is a toothed wheel 7, which gears with a pinion 8 on a shaft 9, and on this shaft is a toothed wheel 10, which gears with a pinion 11 on a shaft 12 of an electric motor 13. Mounted on the frame 1 is a feed box 14 having a passage 15. This passage is directly above the wheel 3, and the pig is fed into



Apparatus for Breaking Pig-Iron.

this passage end on, so that a portion of the pig will project into the path of the teeth 4 of the wheel, and will be broken off by the action of the wheel. Under ordinary conditions the wheel would break the pig and throw it with considerable force, and, in order to absorb the shock and thus prevent the broken pig doing damage and to deflect its movement, a toothed wheel 16 is provided, which is mounted on a shaft 17 mounted in bearings of a suitable framework; the teeth 18 of this wheel are made as clearly shown in Fig. 1, being rounded and curved, and arranged tangentially so that when the piece of pig is broken off it will strike the wheel below the centre of the shaft 17, causing it to turn by its impact, but as the wheel is frictionally mounted it simply moves so as to cushion the blow, and the piece of pig drops on to the inclined chute 19. In order to regulate the friction upon the wheel 16, it is preferable to mount a band wheel 20 on the shaft 17 and pass a band 21 around the wheel, the band being secured to a fixed point at 22 and attached to a lever 23 pivoted at 24. From the end of this lever are suspended adjustable weights 25 so that by adjusting the weights the proper amount of friction can be given to the wheel, so that it will only turn sufficiently to take up the shock caused by the striking of the broken pig against the wheel.

THE "Wilson Premium" for the best Paper read before the Crystal Palace Engineering Society (affiliated to the Society of Engineers, Incorporated), during the present session, has been awarded by the Council to Mr. E. C. Coke, for his Paper on "The Electrification of the L.B. & S.C. Railway."

Trade Talk.

THE CENTRAL ENGINEERING COMPANY, LIMITED, is being wound up voluntarily.

CONSIDERABLE damage was caused by a fire at the engineering works of Messrs. Deas & Company, Sydney Street, Glasgow, on April 26.

THE third May lecture of the Institute of Metals was delivered by Sir J. A. Ewing, who took as his subject the inner structure of simple metals.

BATEMANS' MACHINE TOOL COMPANY, LIMITED, is being wound up voluntarily, with Mr. H. D. Leather, 10, East Parade, Leeds, as liquidator.

A FIRE, which caused heavy damage, occurred at the North-Eastern Foundry of Mr. Charles W. Taylor, in Laygate Street, South Shields, recently.

THE HANWAY ENGINEERING WORKS, LIMITED, are being wound up voluntarily, with Mr. P. Wickenden, 8 and 9, Martin's Lane, London, E.C., as liquidator.

THE RUDKIN ENGINEERING COMPANY, LIMITED, is being wound up voluntarily, with Mr. D. Sibbald, Smith's Bank Chambers, Market Place, Derby, as liquidator.

THE works and plant of the Scunthorpe Foundry Company, of Scunthorpe, Lincs., were recently sold by public auction to Mr. G. W. Miller, manager of the works, for £2,560.

THE SWIFT MACHINE AND GEAR COMPANY, LIMITED, of Clayton West, near Huddersfield, have changed their name to the Clayton West Machine and Gear Company, Limited.

THE STASSANO ELECTRO STEEL AND FURNACE COMPANY, LIMITED, is being wound up voluntarily. Mr. A. Hobbs, 4, Sotheby Road, Highbury, has been appointed liquidator.

THE estates of H. J. Miller & Company, engineers, Glasgow, and Hugh John Miller, the sole partner, were sequestrated on April 20 by the Sheriff of Lanarkshire, at Glasgow.

LOVERIDGE, LIMITED, engineers, Docks, Cardiff, have appointed Messrs. H. M. Lang & Company, 342, Argyle Street, Glasgow, as their agents for Glasgow and the West of Scotland.

ACCORDING to an application made to the local authorities, Hall, Russell & Company, Limited, are proposing to establish a new iron foundry at St. Clement Street and Wellington Street, Aberdeen.

MACFARLANE, STRANG & COMPANY, LIMITED, of the Lochburn Ironworks, Glasgow, have received an order from the Glasgow Corporation Water Department for 3,300 tons of 36-in. cast-iron water pipes.

THOMAS SMITH & COMPANY, LIMITED, ironfounders, of Emmett Street Foundry, Poplar, London, E., have recently added a new branch to their business, viz., that of scrap iron and metal merchants.

WILSONS & MATHIESONS, LIMITED, of the Carlton Works, Canal Road, and Scotch Foundry, Armley, Leeds, have appointed Mr. W. C. Bryant, 42, Main Street, Birmingham, as their Midland agent.

MESSRS. D. BRAMHALL and G. H. Robinson, carrying on business at mechanical engineers, at Coronation Road, Blundellsands, near Liverpool, under the style of Bramhall & Robinson, have dissolved partnership.

THE business belonging to the late Mr. W. L. Turnbull, who traded under the style of John Turnbull, jun., & Sons, Canal Basin Foundry, Dobbie's Loan, Glasgow, has been sold to Mr. Campbell Turnbull, of Glasgow.

THE steel foundry premises of the British Westinghouse Electric and Manufacturing Company, Limited, are now being utilised for other manufacturing purposes. The plant was recently sold at a loss of £36,719 15s. 3d.

THE partnership heretofore subsisting between Messrs. J. Wall and R. D. Laycock, carrying on business as engineers, at 6 and 8, Fairhurst Street, Liverpool, under the style of James Wall & Company, has been dissolved.

A FIRE broke out on May 17, involving premises in Ludgate Hill and St. Paul's Square, Birmingham, partly occupied by Mr. W. Thompson, brassfounder. The frontages of the works were saved, but the interior was gutted.

THE partnership hitherto carried on by A. Wragg, R. Wragg, H. Wragg, and S. Wragg, under the style of E. Wragg & Sons, at Church Gresley, Derby, as engineers and ironfounders, has been dissolved so far as regards Mr. S. Wragg.

NOTICE is given that an order was made on April 30 last, restoring the letters patent granted to A. Musker, W. C. Mitchell, and B. W. Head for an invention for "Improvements in ingot or casting extracting apparatus," numbered 9,312 of 1906.

THE ARC WORKS ENGINEERING SOCIETY held their fifth annual conversazione on Friday, May 3. The entertainment took place in the Arc Works Club House, Writtle Road, Chelmsford, and there was a large attendance of members and their friends.

MR. GRAHAMSLEY, of Newcastle, has just purchased the Pensher Foundry, belonging to the Pensher Foundry Company, Fence Houses, Co. Durham, for about £1,300. The property was recently put up for sale by public auction, and was withdrawn.

STEWARTS & LLOYD'S, LIMITED, are reported to have acquired a large area of ground at Mossend, Lanarkshire, where they intend to erect the necessary buildings and lay down extensive plant for the manufacture of drawn steel tubes. The site of the new works adjoins the main line of the Caledonian Railway.

THE WIDNES FOUNDRY COMPANY, LIMITED, have secured a contract for the supply and erection over the River Quarahim of a railway bridge, composed of 19 trussed girder through steel spans of 33.73 metres each, and 18 pairs of steel cylinders with concrete filling. The total weight of the bridge complete is about 2,500 tons.

A WORKING arrangement has been entered into between the Primus Patents Company and the Falcon Ironworks, Limited, Oldham, whereby all their specialities will, in the future, be manufactured at Oldham. The plant at Trafford Park has, therfore, been removed to Oldham, where all communications are to be sent in future.

THE partnership heretofore subsisting between Messrs. H. B. Watson, J. S. Watson, E. T. White, and R. Christie, carrying on business as founders, at Walker Gate, near Newcastle-upon-Tyne, under the style of Henry Watson & Sons' Iron Foundry, has been dissolved, so far as concerns Mr. E. T. White and Mr. R. Christie

WHAT is considered to be the largest weighbridge in Scotland has just been laid down at the Parkhead Forge, Glasgow, of William Beardmore & Company, Limited, to cope with the great increase in the weight of armour plates, naval guns, and general ordnance. The weighbridge was specially designed by W. & T. Avery, Limited.

WM. COOKE & COMPANY, LIMITED, of Sheffield, have formed an Australian branch, under the style of Wm. Cooke & Company (Australia), Limited, with a capital of £10,000. Messrs Horrocks, Roxburgh Pty., Limited, Sheffield House, Little Collins Street, Melbourne, have been appointed the Company's agents for Victoria, Tasmania, and South Australia. An office has been opened at Sydney to deal with business in New South Wales and Queensland. Wm. Cooke & Company (New Zealand), Limited, of Auckland, will represent the Company in New Zealand.

PEASE & PARTNERS, LIMITED, of Darlington, took over, on May 1, the Tees Iron Works, Middlesbrough, hitherto owned by Wilsons, Pease & Company, Limited. Messrs. Pease & Partners have also acquired the Normanby Ironworks, at Middlesbrough, and both the firm's new undertakings will be conducted from the Tees Ironworks, under the joint management of Messrs. R. Theodore Wilson and J. Callum. The former has been identified with Messrs. Wilsons, Pease & Company for many years, and Mr. Callum has been successfully associated with the Normanby Ironworks for some time past.

THE members of the National Light Castings Association, who met in Glasgow on April 26, held meetings

in Larbert on April 27, on the invitation of the Carron Company. There was a large attendance of representatives from foundries throughout Great Britain and Ireland, and the meeting discussed various important phases of the light casting trade. In the afternoon the representatives were entertained to luncheon by the Carron Company, and afterwards a golf match took place between the Scottish and English delegates. In the evening the company assembled in the Larger Dobbie Hall, Larbert, on the invitation of the Carron Company, there being over 100 present.

THE large stern frame and rudder brackets which have been cast at the Darlington Forge for the new Cunarder "Aquitania," were removed on April 28 to Middlesbrough by special train, for shipment to John Brown & Company's shipyard, Clydebank. The main part of the stern frame weighed 50 tons, and with the connecting pieces, including the bridge and nosepiece and the propeller brackets, made a total of about 130 tons. Two 25-ton locomotive steam cranes were requisitioned for lifting and adjusting the load, and a special North-Easter 54-ton trolley wagon was used for the main section. Both sets of rails had to be kept clear during the course of the journey, and it was only with difficulty that the load was adjusted to enable it to clear some of the bridges.

THE regulations made by the Board of Trade under Part II. of the National Insurance Act of 1911 were issued on May 11. These regulations place in the hands of employers the custody of workmen's unemployment books issued by the Board, subject to inspection by the men not more than once a month. Employers are to be entitled to deduct from wages half the value of stamps they affix to workmen's books. Further, the regulations prescribe the procedure under which the workmen may obtain unemployed benefit from workmen's associations and direct from the local labour exchanges. As regards courts of referees, it is laid down that members of the panel to represent employers in a district are to be appointed by the Board and the workmen's panel by the workmen, the terms of office in each case on first appointment being not less than one year or more than three, but subsequently for three years. A court is to consist of a chairman, appointed by the Board, and one member from each of the two panels.

THE statement of affairs filed by H. A. Simmonds (trading as F. H. Simmonds), 22 and 24, New Charles Street, Goswell Road, and 43, Hall Street, City Road, London, E.C., brassfounder, shows liabilities £1,240 5s. 4d., of which £930 9s. are returned as expected to rank for dividend, and estimated net assets £218 19s. 2d. The public examination of the debtor was held on May 14 at the London Bankruptcy Court before Mr. Registrar Linklater. The debtor's business was established by his father over fifty years ago. In March, 1908, his brother left him the business, which, as a matter of fact, was then insolvent, but he decided to continue the trading, having borrowed a little capital. This was, however, not a success, and two years ago he was compelled to obtain loans from professional moneylenders. In February last he was severely pressed by his creditors, and one of them then presented the petition on which the recognised order was made. The debtor attributed his failure and insolvency to his having taken over an insolvent business in 1908; also to want of capital and to loss on trading. His Honour ordered the conclusion of the examination.

AT the meeting of the Birmingham Metallurgical Society on Tuesday, May 14, a paper was given by Mr. A. H. Hiorns, head of the Metallurgical Department of the Birmingham Municipal Technical School, on the subject of "Metallurgical Progress During the Last Forty Years." Mr. J. H. Stansbie, the President, called attention to the pending retirement of Mr. A. H. Hiorns from the school, and spoke very appreciatively of his work. Mr. Hiorns dealt very comprehensively with his subject. He pointed out that before the introduction of the Bessemer process, railway tyres cost £90 per ton, cast steel bars £40, and steel plates £50. The effect of the introduction of the Bessemer process was at once to reduce the price by nearly two-thirds. As an instance of the growth in the use of machinery, the speaker cited the "mixer," which, at first, was constructed to hold 100 tons, but was now commonly of 300- or 400-tons capacity, and in one case 750-tons. The ordinary size of ingots had increased from two to five tons, instead of 18 to 25 cwts. formerly. Plates are 12 ft. wide, and whereas forty years ago the maximum output of a mill was 50 per shift, now it was 400 tons

VISCOUNT HALDANE on May 18 opened the new engineering laboratories at Liverpool University, which have cost £40,000 to build, and another £30,000 to equip. His Lordship testified to the importance of such enlarged opportunities as were now given to students for initiative in engineering in such a centre as Liverpool, and dwelt on the value of the universities to the great cities in fostering the abilities of their most capable citizens. The equipment of the laboratories is in every way up-to-date. The latest types of internal combustion engines, including Diesel, semi-Diesel, and other gas and oil engines, together with a complete installation of air compressors have been installed. Very comprehensive arrangements are made for fuel testing and gas analysis, while in the applied heat laboratory a refrigerating machine is installed. The equipment in hydraulics and for the testing of materials of construction is very thorough. Large rooms are also set aside for dynamics and kinematics of machines, transmission of power, fan testing, and the microscopic examination of metals. Workshops, large drawing halls, and numerous lecture rooms and private rooms have also been provided. The electrical engineering laboratories, which were opened in 1905, occupy a separate but adjacent site. The School of Naval Architecture is housed in a part of the original University buildings, while the civil engineering department occupies a portion of the Walker engineering laboratories.

A PAMPHLET has been issued setting forth the origin and purpose of the British Engineers' Association, which was incorporated on April 26 last. The aim of the Association is to establish itself as a national organisation for the promotion on the broadest lines of the overseas interests of the British engineering industry. The efforts of the Association will in the first place be directed to China. In that country, especially in view of the new régime, the organisation and strengthening of British engineering interests is urgently needed. The technical education of Chinese engineers on British lines and in the English language will be encouraged. The following is a complete list of the members at the time of incorporation of the Association:—W. H. Allen, Son & Company, Avonside Engine Company, Babcock & Wilcox, British Aluminium Company, British Insulated and Helsby Cables, Peter Brotherhood, Brown, Bayley's Steel Works, Brush Electrical Engineering Company, Callender's Cable and Construction Company, Campbell Gas Engine Company, Chloride Electrical Storage Company, T. Cooke & Sons, Craven Brothers, Crossley Brothers, Dick, Kerr & Company, Fielding & Platt, George Fletcher & Company, Fraser & Chalmers, Richard Garrett & Sons, Glenfield and Kennedy, W. T. Glover & Company, E. Green & Son, Hadfield's Steel Foundry Company, J. & E. Hall, Hardy Patent Pick Company, Hayward-Tyler & Company, Heenan & Froude, Alfred Herbert, Holden & Brooke, Holman Brothers, John Oldroyd & Company, Hughes & Lancaster, Richard Johnson & Nephew, H. R. Marsden, Marshall, Sons & Company, Mather & Platt, Midland Railway Carriage and Wagon Company, Miller & Company, McKie & Baxter, North British Locomotive Company, Platt Brothers & Company, Power Gas Corporation, A. Ransome & Company, Ransomes & Rapier, Ransomes, Sims and Jefferies, Robey & Company, Rose, Downs & Thompson, Royce, Ruston, Proctor & Company, Sandycroft Foundry Company, Smith's Dock Company, Stewarts & Lloyds, Stothert & Pitt, John I. Thornycroft & Company, E. R. & F. Turner, Vickers, Vulcan Foundry, Walker Brothers (Wigan), J. Samuel White & Company, Willans & Robinson, Edward Wood & Company. The offices are at 38, Queen Anne's Chambers, Westminster, S.W.

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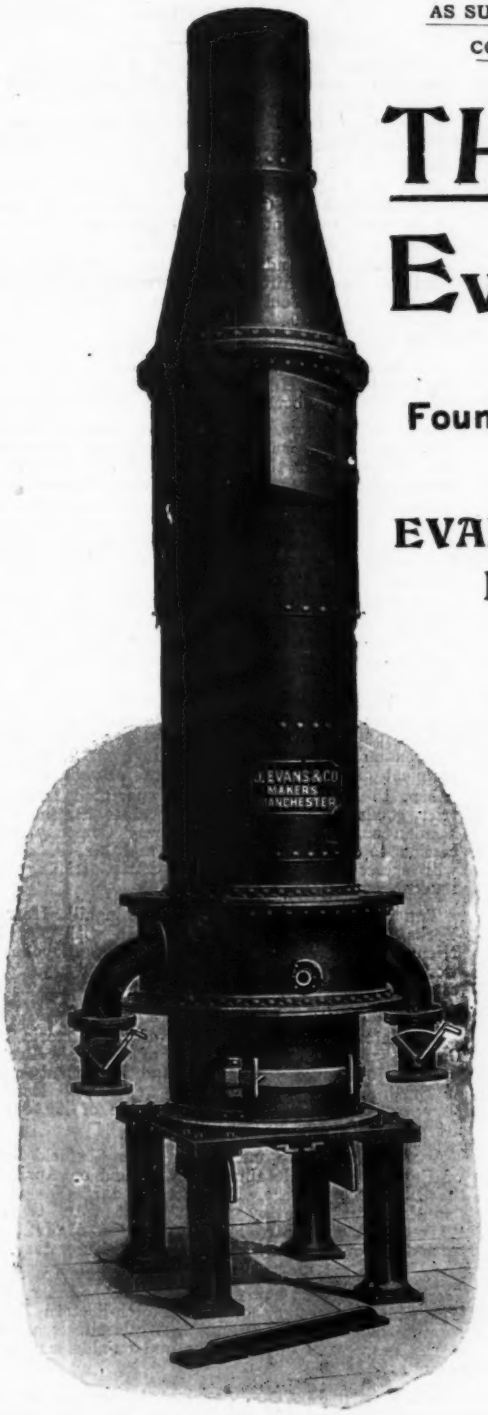

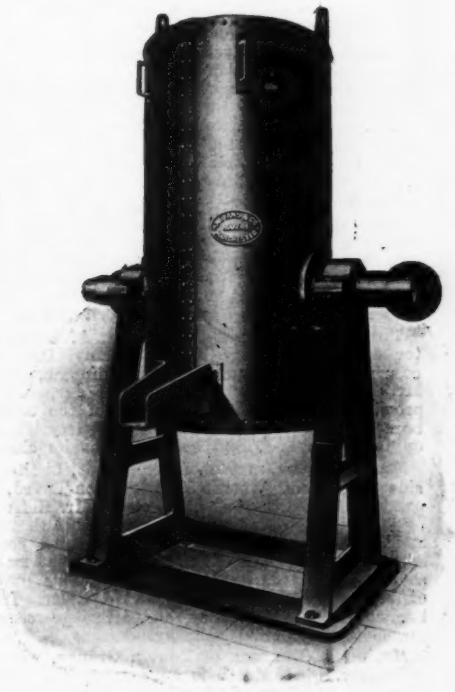

James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

Deaths.

MR. N. GREEN, a director of Marsden's Engines, Limited, died recently, aged 71 years.

MR. D. M'PHERSON, of the late firm of M'Pherson & Aitken, ironfounders, Glasgow, died recently.

MR. H. H. COX, J.P., of Messrs. Cox & Company, engineers, Falmouth, died recently, aged 70 years.

THE death occurred on May 1 of Mr. A. McBain, head of A. McBain & Company, engineers, of Cornhill, London, E.C.

MR. C. J. CARTER, at one time a director of the Maldon Ironworks Company, Limited, died recently at the age of 91.

MR. A. T. LYDEARD, at one time sole proprietor of the Dudbridge Ironworks, Camscross, Glos., died recently, aged 77 years.

MR. E. HILL, manager to Spear & Jackson, Limited, crucible steel manufacturers, Etna Works, Sheffield, died recently, aged 92 years.

MR. WILLIAM RITCHIE, of the firm of Grant, Ritchie & Company, engineers, Townholm Engine Works, Kilmarnock, died recently, aged 75 years.

THE death is announced of Mr. J. Johns, who was associated with the Uskside Engineering and Rivet Company, Limited, and John Lysaght, Limited.

MR. J. HILDICK, of Messrs. Hildick & Hildick, malleable ironfounders and tube manufacturers, Walsall Tube Works, Walsall, died recently at the age of 56 years.

THE death took place in Glasgow, on May 13, at the age of 65, of Mr. William Wallace, the managing director of John Wallace & Sons, Limited, agricultural implement makers and engineers.

THE death took place recently, at 3, Woodlands Terrace, Middlesbrough, of Mr. G. Marsh, manager of the Bessemer department of the North-Eastern Steel Company, Limited. He was 70 years of age.

THE death took place at Havant, Hants, recently, of Sir James Roffey, at the age of 80 years. He had served thirty-six years in the engineering branch of the Royal Navy, retiring in 1888 with the rank of Chief Inspector of Machinery.

SIR JULIUS WERNHER, Bart., died on May 21 at his residence in London. Sir Julius, who was 62 years of age, was the well-known Rand magnate, and head of Wernher, Beit & Company. In addition to his numerous mining and banking connections, he was chairman of Fraser & Chalmers, Limited, of Erith, Kent.

THE death is reported of Mr. R. A. Groom, a director of the Haybridge Iron Company, Limited, which occurred at his residence at Wellington, on May 3. Mr. Groom, who was 66 years of age, had taken a prominent part in the public life of the town, having been a member of the Urban Council from its formation up to March last, and had acted as its chairman.

MR. W. ELDER, of Wm. Elder & Sons, Limited, Tweedside Implement Works, Berwick-upon-Tweed, died recently at Polwarth House, Berwick. Mr. Elder, who was 75 years of age, had been in failing health for several months. From 1851 until 1862 he gained considerable experience with various firms of implement makers, and shortly afterwards started business on his own account under the name of Lillie, Goodlet & Elder. In 1879 he became the sole proprietor, and a few years ago it was turned into a limited company.

MR. JOHN GWYNNE, of Kenton Grange, near Harrow, Middlesex, whose death is announced, was chairman of Gwynnes, Limited, of 81, Cannon Street, London, E.C. Mr. Gwynne was born in 1837, educated at Bruce Castle and Esher, and entered his father's Essex Street Engineering Works as an apprentice in 1853. In 1867, in conjunction with his brother Henry, he founded the Hammersmith Iron Works for the manufacture of centrifugal pumping machinery, under the title of J. & H. Gwynne. This business was in 1897 converted into a limited company, and in 1903 the ancient engineering works of Gwynne & Company, of Essex Street, and Brooke Street, were united with J. & H. Gwynne, Limited, under the direction of Mr. John Gwynne.

Personal.

THE gross value of the estate of the late Mr. L. E. Crawford, retired ironfounder, of Oakdene, Elton Road, Clifton, Bristol, is £23,138.

THE late Mr. C. Hodgson, chairman and managing director of Saxby & Farmer, Limited, engineers, left estate of the gross value of £14,835.

MR. F. J. MAW, who in December last retired from the secretaryship of Cammell, Laird & Company, Limited, is to be the recipient of several handsome gifts from the officials and men.

THE late Mr. Andrew M'Millan, of Castlehill House, Carluke, Lanarkshire, formerly agent in Glasgow for the Shotts Iron Company, Limited, left personal estate valued at £43,319.

MR. T. S. CATMUR, manager for Messrs. C. W. Burton, Griffiths & Company, merchant engineers, of 1, Ludgate Square, Ludgate Hill, London, E.C., has just returned from a visit of about five weeks in the United States.

MR. D.D. EVANS, of Pontardawe, has been appointed manager of the Dulais Tinplate Works, Pontardulais. Mr. Evans is at the present time the chief clerk at Messrs. Gilbertson's Tinplate Works, Pontardawe.

THE late Mr. Nathaniel Greenwood, a member of the firm of Messrs. Marsden & Company, engineers and ironfounders, now known as Marsden's Engines, Limited, left estate valued at £10,669 gross, with net personalty £10,608.

COLONEL J. R. WRIGHT, V.D., chairman of Baldwins, Limited, and Dillwyn & Company, Limited, and a director of the Port Talbot Steel Company, Limited, has been appointed a deputy-lieutenant for the County of Glamorgan.

MR. W. E. HAMPTON, who has for the past eleven years been manager of the steel department of the Newburn Works, of John Spencer & Sons, Limited, and who has secured an appointment in Birmingham, has been the recipient of a presentation from the officials and men.

MR. F. A. SARGENT has been appointed London district goods manager at Broad Street Station of the London and North-Western Railway Company, in succession to Mr. I. T. Williams, and Mr. J. Roughley will succeed Mr. Sargent as district traffic superintendent at Garston Dock.

THE late Mr. W. Wilson, of Sunninghill, Harrogate, Yorks., who entered into partnership with Mr. Ralph Nicholson, of Ryton, and took over the Blaydon Ironworks, which they carried on for twenty years, left estate of the gross value of £61,793 13s. 7d., with net personalty £61,667 4s. 7d.

THE late Mr. J. T. Teasdale, of 28, Victoria Place, Darlington, one of the founders of Teasdale Brothers, Limited, agricultural engineers and implement makers, of Darlington, who died on the 9th March last, aged 66 years, left estate of the gross value of £9,704, with net personalty £3,860.

A MEETING of the members of the Sheffield Society of Engineers and Metallurgists was held on April 22 in the Old Firth College, Bow Street, Sheffield. A presentation was made by the President (Mr. G. Blake Walker, J.P.) to Mr. F. K. Knowles, B.Met., as a recognition of his many years' service as secretary.

MR. S. T. HARRISON had the honorary freedom of Wallsend conferred upon him on May 15. Mr. Harrison, who is secretary of the North-Eastern Marine Engineering Company, Limited, Wallsend, is a Justice of the Peace, and an ex-mayor and ex-alderman of the borough.

MR. JOSEPH ROSTERN, assistant to the general manager of the Great Central Railway, has been appointed to succeed the late Mr. C. T. Smith as chief goods manager. Mr. A. E. Clear, the assistant goods manager, will succeed Mr. Rostern as assistant to the general manager, and Mr. Edwin Liversley, the chief goods traffic canvasser, will follow Mr. Clear as assistant goods manager.

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The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

Metals.	End May, 1912.	End May, 1911.
Iron—Scotch pig warrants ton	*59/10½	*52/9
—Middlesbro' warrants ... ton	54/0½	46/10½
—W.C. M/nos Bessemer ... ton	72/0	65/0
—Stock, Scotch ... ...tons	1,000	1,000
Copper—Chili bars, GMB ton	£75 15 0	£55 2 6
—Stock, Europe and afloat tons	55,542	94,768
Tin—English ingots ... ton	£210 10 0	£197 10 0
—Straits ... ... ton	£204 5 0	£203 15 0
—Stock, London, Holland, U.S.A., and afloat ...tons	12,812	14,696
Lead—English pig ... ton	£17 0 0	£13 7 6
Spelter—Ord. Silesian ... ton	£25 15 0	£24 8 9
Quicksilver (75lb)... bottle	£8 5 0	£8 5 0
Antimony—Regulus .. ton	£27 0 0 £28 0 0	£29 10 0
Aluminium—Ingot ... ton	£67 0 0	

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	5 7 6	to	5 15 0
,, 3 to 4 in.	5 2 6	to	5 5 0
,, 5 to 8 in.	5 0 0	to	5 2 6
,, 10 to 16 in.	5 0 0	to	5 2 6
,, 18 to 24 in.	5 0 0	to	5 2 6
Chairs	3 15 0	to	3 17 6
Floor plates (open sand)	3 5 0	to	3 7 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows : Heavy wrought (mixed), £2 10s. 0d.; light wrought, £1 5s. 0d. ; heavy cast, £2 10s. 0d. ; all per ton, f.o.b., London. Copper (clean), £68 10s. 0d. ; brass (clean), £46 0s. 0d. ; lead (usual draft), £15 15s. 0d. ; zinc, £20 10s. 0d.; all per ton delivered merchant's yard.

New Companies.

BECK ENGINFERING COMPANY, LIMITED.—Capital £20,000 in £1 shares.

BRITISH ENGINEERS' ASSOCIATION.—Registered April 26. Limited by guarantee.

GRIMSBY FOUNDRY COMPANY, LIMITED.—Capital £1,000 in £1 shares. Registered office : Albert Street, Grimsby.

WHITELEY, TANSLEY & COMPANY, LIMITED.—Capital £500 in £1 shares, to carry on the business of engineers, etc.

BERMONDSEY METAL WORKS, LIMITED.—Capital £100 in £1 shares. Registered office : 15, Union Road, Bermondsey, S.E.

ARGENTINE IRON & STEEL COMPANY (Pedro Vasena E Hijos), LIMITED.—Capital £1,000,000 in £1 shares (500,000 Pref.).

BRISTOL ENGINEERING COMPANY, LIMITED.—Capital £3,000 in £10 shares. Registered office : 10, New Station Road, Bristol.

D. G. SOMERVILLE & COMPANY, LIMITED.—Capital £15,000 in £1 shares (8,000 preference), to carry on the business of engineers, etc.

MILLER ANTI-FRICTION METAL COMPANY, LIMITED.—Capital £1,200 in £1 shares. Registered office : 3, Gore Street, Piccadilly, Manchester.

NELSON TOOL COMPANY, LIMITED.—Capital £5,000 in £1 shares, to carry on the business of steel and general merchants and manufacturers, agents, etc.

ARROL-JOHNSTON, LIMITED.—Capital £100,000 in £1 shares, to acquire and carry on the business of engineers, etc. Registered office : Underwood Road, Paisley.

MARRIOTT & STEWART (1912), LIMITED.—Capital £2,000 in £1 shares, to carry on the business of engineers, etc. Registered office: 6, Holborn Viaduct, E.C.

JOHN S. WALFORD & SON, LIMITED.—Capital £12.000 in £1 shares, to carry on the business of brass founders, etc. Registered office: 62-3, Hampton Street, Birmingham.

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FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams : "LOWOOD, DEEPCAR."

WE SUPPLY THE LEADING FIRMS IN THE TRADE WITH
FOUNDRY BLACKINGS
OF ALL KINDS,
COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD, CORE GUMS and all Foundry Requisites, and have done so since 1831.
I. & I. WALKER, EFFINGHAM MILLS, ROTHERHAM.
Our Specialite is Studying Special Requirements.
KINDLY HAND US YOUR ENQUIRIES.

Established 1863.

JAS. DURRANS & SONS,

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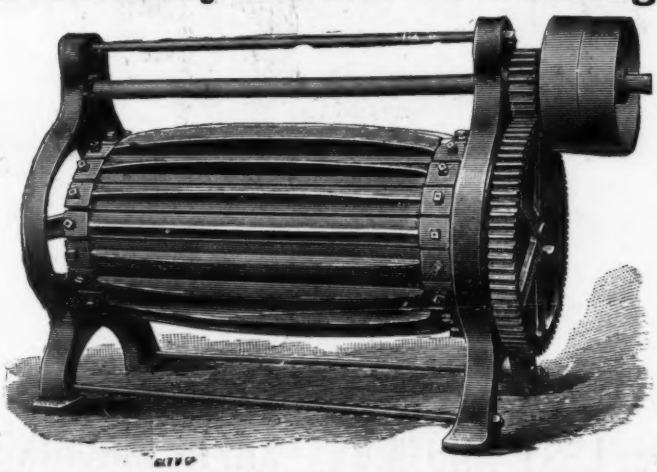
FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

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Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

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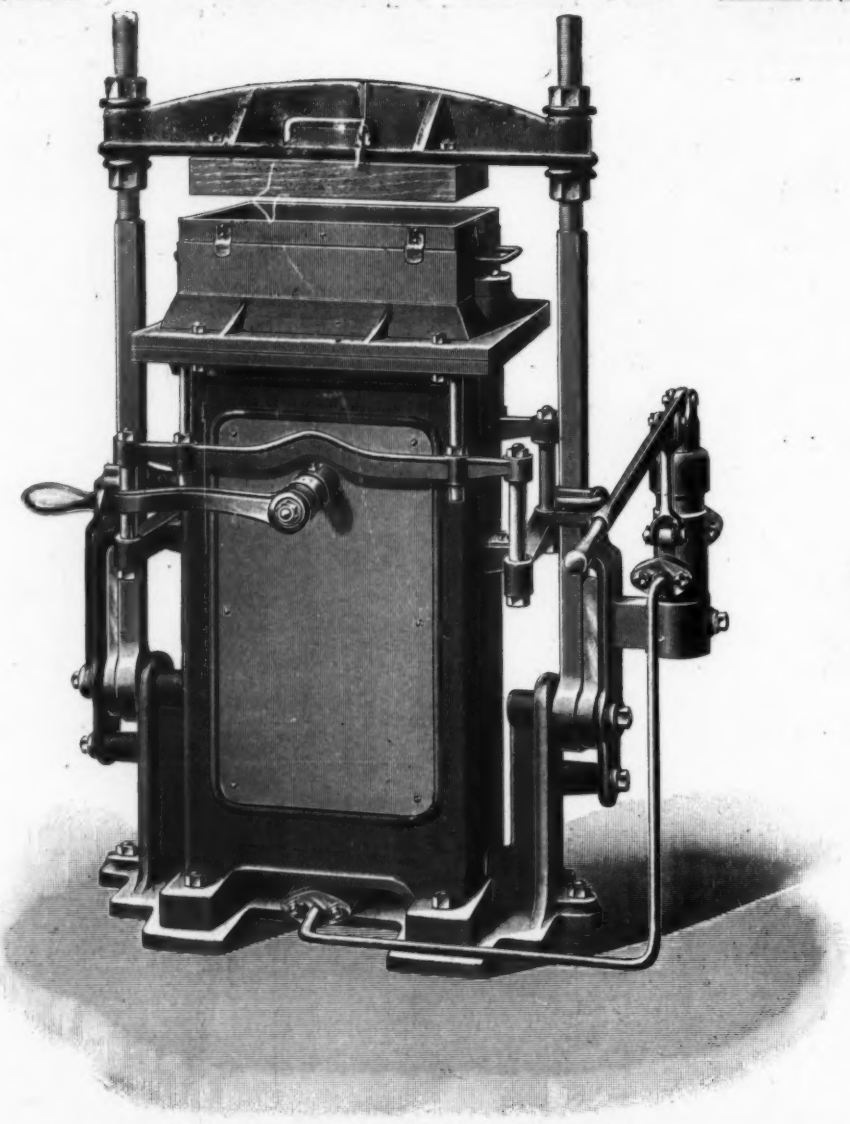
TOTTENHAM, LONDON, N.

TELEPHONE: TOTTENHAM 158 (TWO LINES)



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THE SIMPLEST AND MOST RAPID MACHINE MADE.

The working parts are so conveniently arranged and operate with such facility that a mould can be rammed and put down on the floor in ¾ minute. This means that the moulder can produce three times as many boxes as by hand and, further, every mould is perfect and all castings alike.

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Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Jackman, J. W., & Co., Ltd.
Marshall & Co. Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
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Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

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British Aluminium Co., Ltd.

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Phillips, J. W. & C. J.
Tilghman's Patent Sand Blast Co., Ltd.

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Jackman, J. W., & Co. Ltd.

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Durrans, Jas., & Sons.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Blacklead.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co.,Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

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Jackman, J. W., & Co., Ltd.
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Marshall & Co., Horace P.
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Olsen, Wm.
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Walker, I. & I.

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Walker, I. & I.
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Marshall & Co., Horace P.
Phillips, J. W., & C. J.

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Olsen, Wm.

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Durrans, J. & Sons.
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Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.
Wilkinson, Thos, & Co.

Core Gums.
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Hall, Charles, & Co.
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Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd

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Jackman, J. W. & Co., Ltd.
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Marshall, H. P. & Co.
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Jones & Attwood, Ltd.
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Phillips, J. W. & C. J.
Portway, C. & Son.

Core Ropes.
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Wilkinson, T. & Co.

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Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

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Vaughan & Son, Ltd.
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Hall, Charles, & Co.
Olsen, Wm.

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Jackman, J. W., & Co., Ltd.

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Phillips, J. W. & C. J.

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Phillips, J. W. & C. J.

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Hall, Charles & Co.
Jackman, J. W. & Co., Ltd.
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Marshall, H. P. & Co.
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London Emery Works Co.

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Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
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Mitchells Emery Wheel Co.

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Olsen, William

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Jackman, J. W., & Co., Ltd.
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Thwaites Bros., Ltd.

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Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
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Jackman, J. W., & Co., Ltd.
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Pickles, James.

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London Emery Works Co.

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Frodair Iron and Steel Co., Ltd., The
Goldendale Iron Co., Ltd.

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Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd,
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Tilghman's Patent Sand Blast Co., Ltd.

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Phillips, J. W. & C. J.

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Halls Eng. Co.
Jackman, J. W. & Co., Ltd.
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Phillips, J. W. & C. J.

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Evans, J., & Co.
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Alldays & Onions Pneumatic Eng. Co., Ltd.
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Olsen, Wm.

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Olsen, William.
Wilkinson & Co., Thos., Ltd.

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Marshall, H. P., & Co.
Phillips, J. W. & C. J.

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National Time Recorder Co
"Stockall-Brook" Time Recorders Co.

Tuyeres (Firebrick).
Dyson, J. & J. [Ltd.
Lowood, J. Grayson, & Co.

Welding. Thermit, Ltd.

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Whittington Blacking Mills, Chesterfield, Eng
Sunnyside Blacking Mills, Falkirk, N.B.
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"Cumming, Whittington, Chesterfield.
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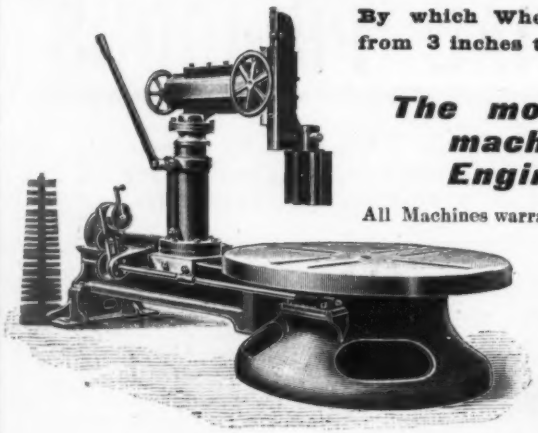

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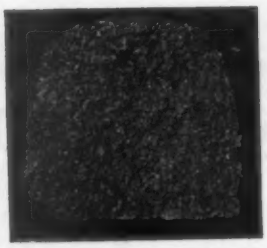
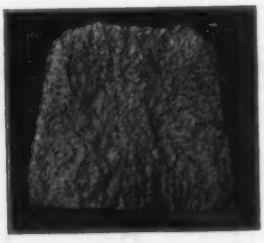

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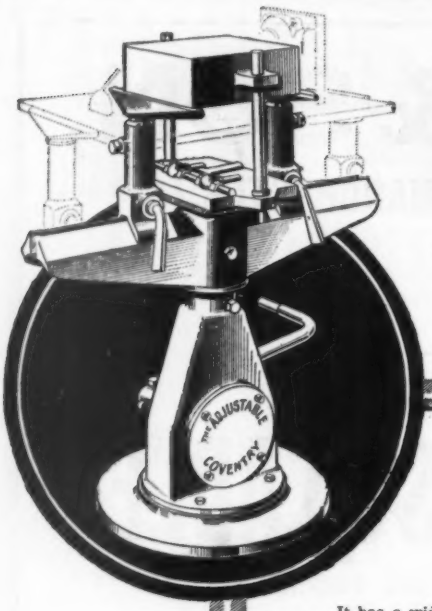

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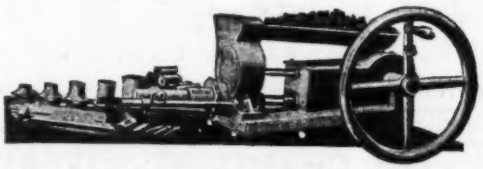

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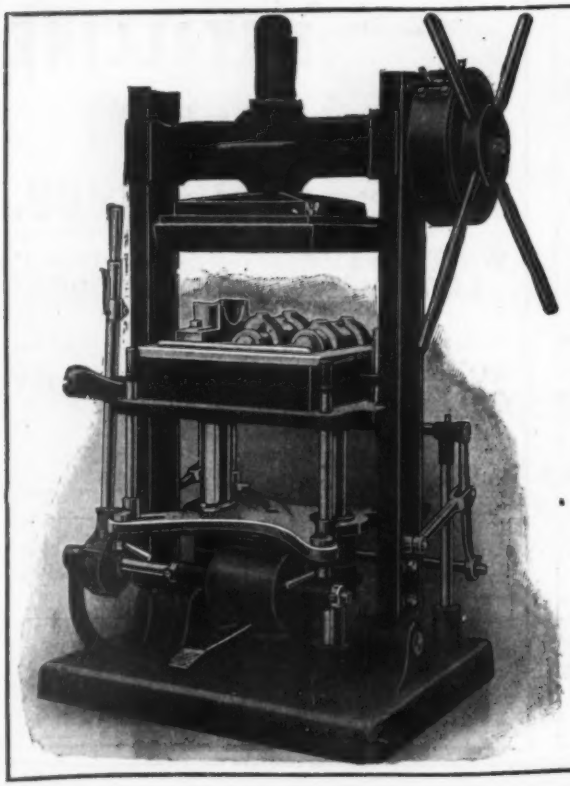

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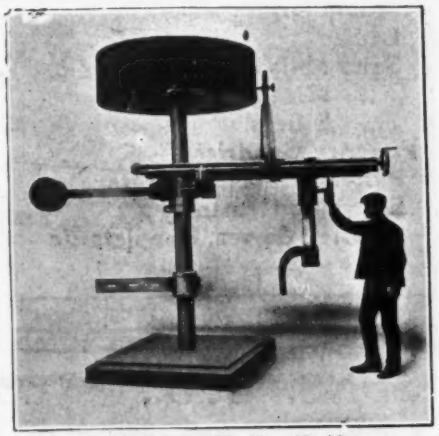

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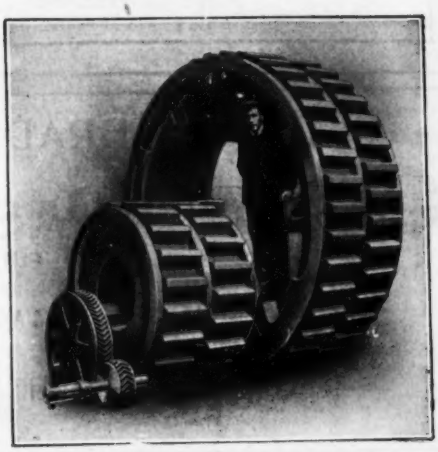

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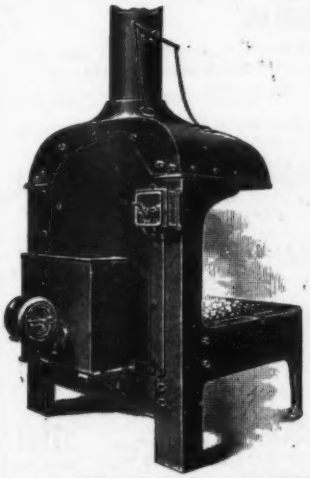

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(Signed) W. B. LAKE, Director

Makers: C. PORTWAY & SON, TORTOISE STOVE & PORTWAY PORTABLE OVEN WORKS, HALSTEAD, ESSEX.

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The Handiest and Cheapest Barrow in the market. Specially designed for coal, dross, ashes, etc. Its capacity is **25 per cent.** greater than the ordinary style, yet it can be wheeled with **half the labour**, and can be emptied **much more quickly.** It is a **perfectly balanced** barrow, and a full load can be **easily wheeled by a boy.**

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BRABY for high grade **STEEL**
SHEETS & PLATES up to 15 FEET LONG.
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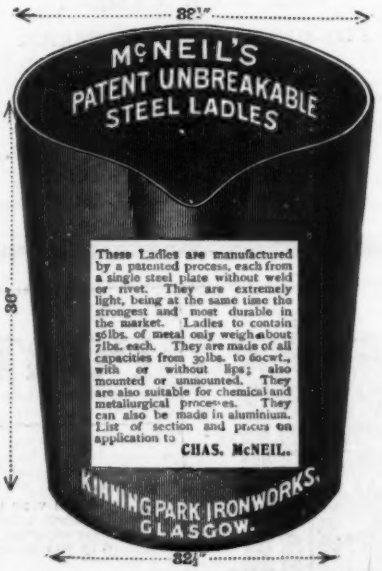
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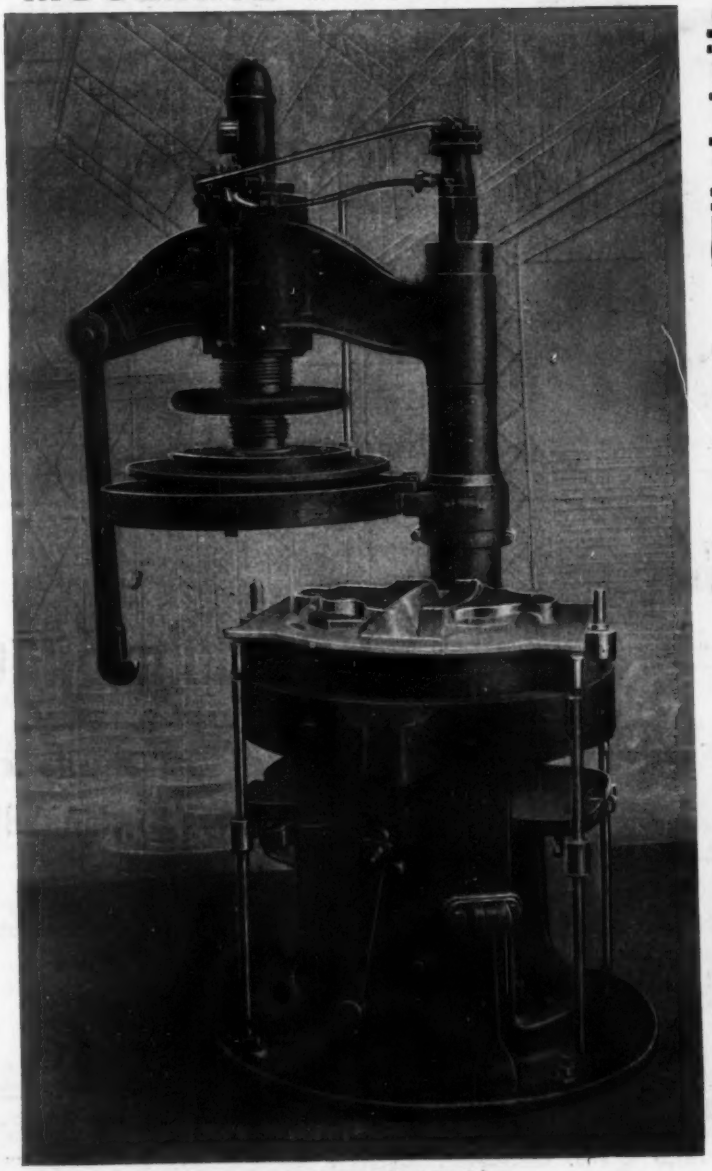

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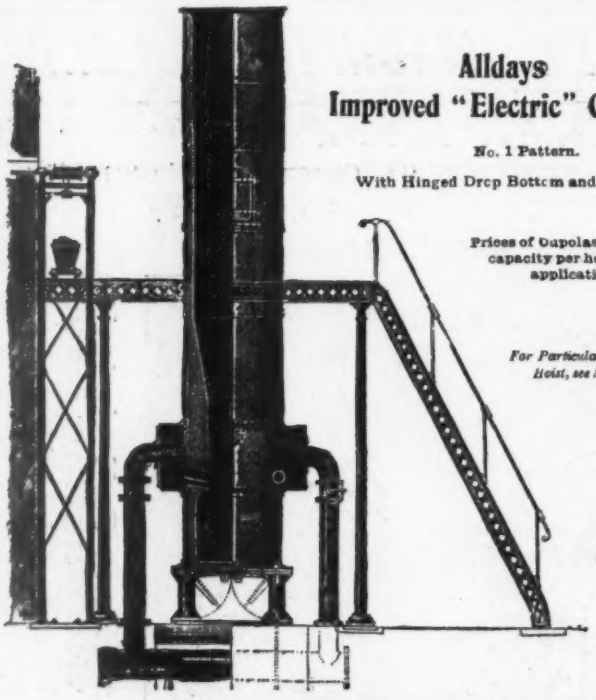
This is a reversible Pattern Plate, with Stripping Plate of a **Railway Carriage Brake Block.**
Output: 15 to 20 Moulds (30 to 40 castings) an hour. Two Men. Round cores in green sand made in the mould itself.



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No. 1 Pattern.

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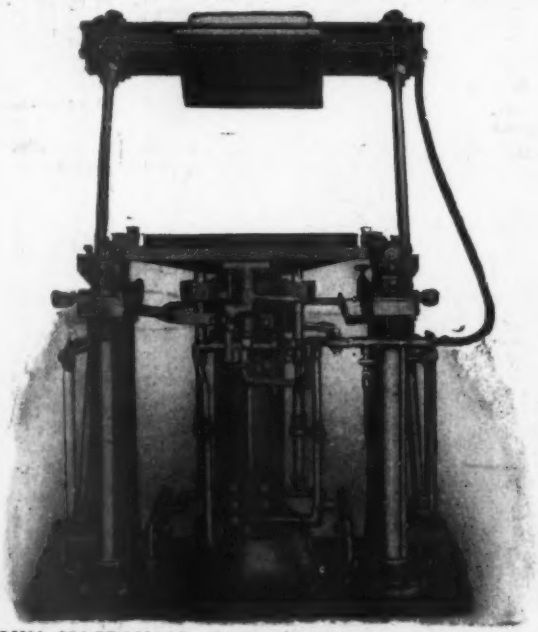

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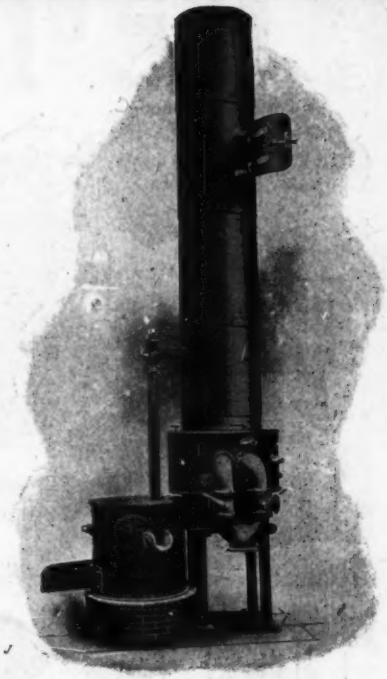
Roots' Blowers,

belt, steam-engine, or electro-motor driven.

Charging Platforms, Hoists, and Ladles.



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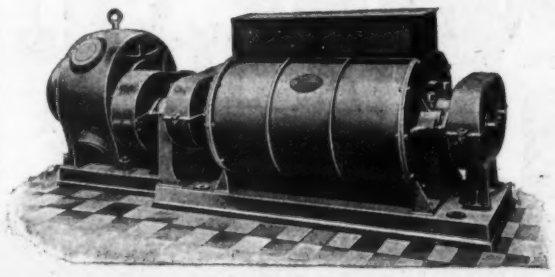

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